This includes various schists, of which chloritic schist, mica schist, hornblende schist, and hornblende rocks are the principal. These rocks are mostly of dark green, bluish green, and dark blue, almost black colour, which makes them very conspicuous wherever they outcrop. They have evidently been much altered by great pressure, and it is not uncommon to find schists which have assumed a highly trappoid appearance, as may be seen in the instance of the Parasi hill. My time was, however, too limited to enable me to study the structure of the metamorphic rocks and their connection with the gneissic formation in detail. But from what I have seen, I believe they form two main folds represented by the northern and southern branch of the main hill ranges, which are enfolded in the gneissic formation in such a way that the latter appears again between the two ranges. The accompanying diagramatic section (Plate II) will illustrate this relation of the two series.

In their various states of development the transition rocks form the main hill ranges, as described in part I of this paper

In close connection with and cutting through these rocks are veins, of which two groups may be distinguished.

The first group represents dykes, probably of diorite, the second quartz veins. The diorite dykes are less numerous than the quartz veins; these, however, cut through the schists in every direction. I could not, however, ascertain whether one direction is prevailing.

There are two different varieties of quartz; the first and more common one is amorphous, of a perfectly white colour and not honeycombed. It may be met with everywhere in the area of the metamorphic rocks and is very common amongst the pebbles of the river-gravels. The second variety is crystalline, and looks like a breccia, as it consists of numerous single crystals cemented together in the same direction,—that is to say, with their prismatic sides, the shape of the single crystals however, being much deformed. A piece of such quartz affords therefore a highly characteristic appearance, which cannot be mistaken The quartz is semi-lucid, of brown or reddish-brown colour, the lines of junction between the single crystals being sometimes filled out with a red stuff, probably hydroxide of iron. This quartz is honeycombed, and contains frequently a black mineral, probably tourmaline.

This variety I only noticed in the Sonapet valley near the village of Roladih; as, however, it was nearly perfectly concealed by débris, I am unable to say whether it forms a regular vein, or only a lenticular-shaped mass imbedded in the surrounding strata. It is also an open question whether it belongs to the transition or gneissic formation; I feel, however, inclined to adopt the latter view.

In neither variety of quartz could I find gold; and unless further discoveries prove the actual existence of gold-bearing quartz, the question of the existence of such reefs must remain doubtful. At any rate, the present examinations have not yielded such information as to prove the existence of auriferous reefs.

3. *The alluvial deposits.*—The alluvial deposits, which are more or less developed all over the country, are of two different kinds: different as regards the way in which they have been formed, different also as to their appearance. They are the following ones:—

(*a*) Red clay, including laterite.

(*b*) River sands and gravels.

(*a*) *Red clay.*—The red clay is the result of the superficial disintegration of chiefly the gneissic formation. I do not doubt that the disintegration of the transition rocks will result in a similar product, but the typical red clay is only well seen there where the gneissic formation is to be found underneath. The red clay is rather tough, of dark red colour, and contains a high percentage of iron, which is frequently concentrated in small irregular nodules; it is frequently noticed that these nodules are cemented together while the clay has been washed off, with the final result of forming a bed of laterite, as for instance south of Lamar. If washed the red clay leaves a black, heavy fine-grained sand, in which occasionally a small show of gold may be found. The red clay is well developed in the northern plains; it is also to some degree found in the Sonapet valley, where the iron ore from it has formerly been used for smelting purposes. My conclusion concerning the presence of the gneissic formation in the Sonapet valley is chiefly drawn from the existence of the red clay therein deposited. The red clay is much less developed in the hill ranges, although it may be seen here and there.[1]

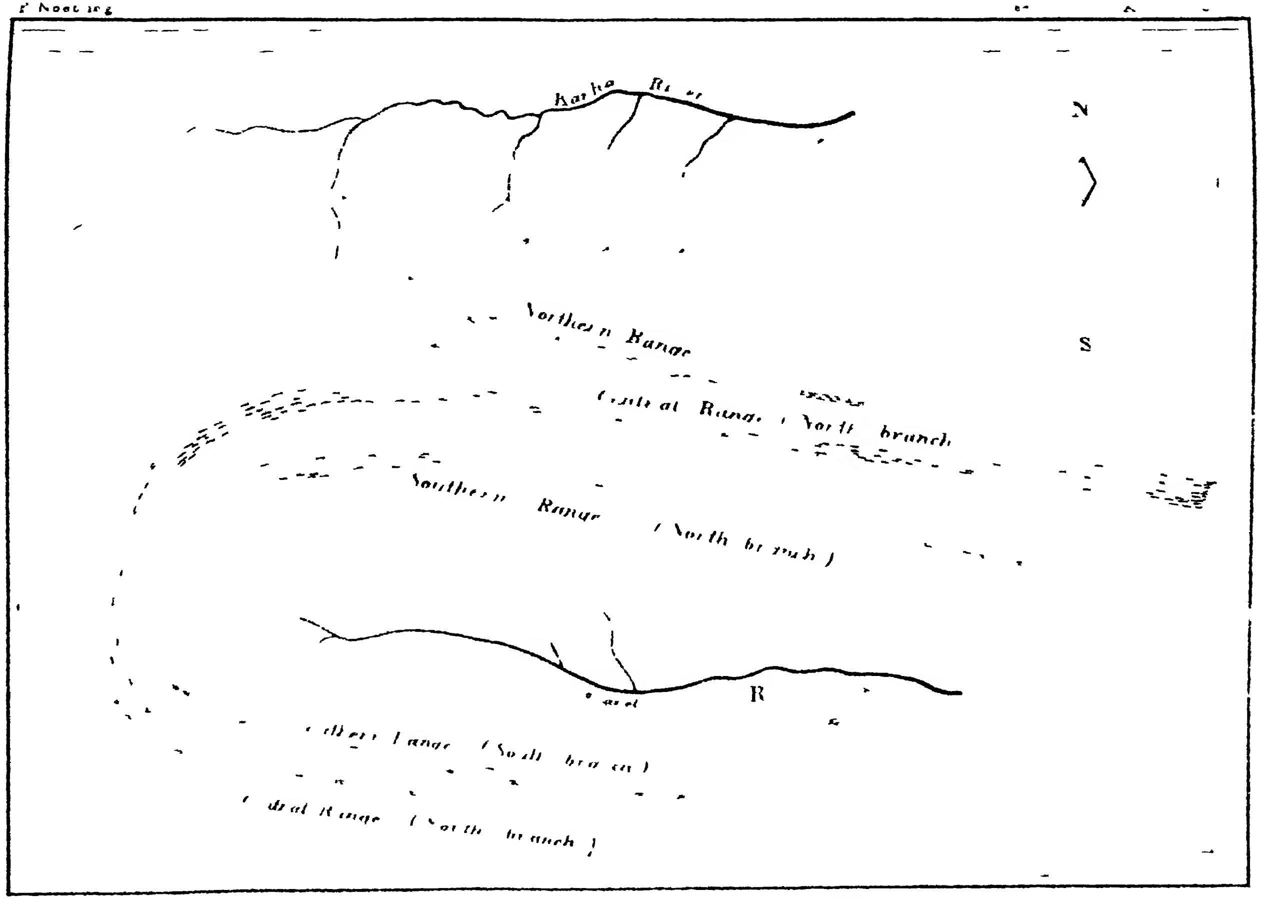
(*b*) *River sands and gravels.*—The river sands and gravels are especially found in the valleys in various grades of coarseness. They chiefly consist of the debris of siliceous schists and hornblende rocks with numerous fragments of white quartz. The finest sand is perfectly black, owing to a large percentage of magnetite iron or titanite; such sand resembles perfectly that obtained by washing the red clay; it may be considered as the special gold bearing sand. Sand of this quality is particularly noticed in the valley, between the central and southern range north of the Sonapet valley; it is also noticed in all the small water-courses traversing the Sonapet valley.

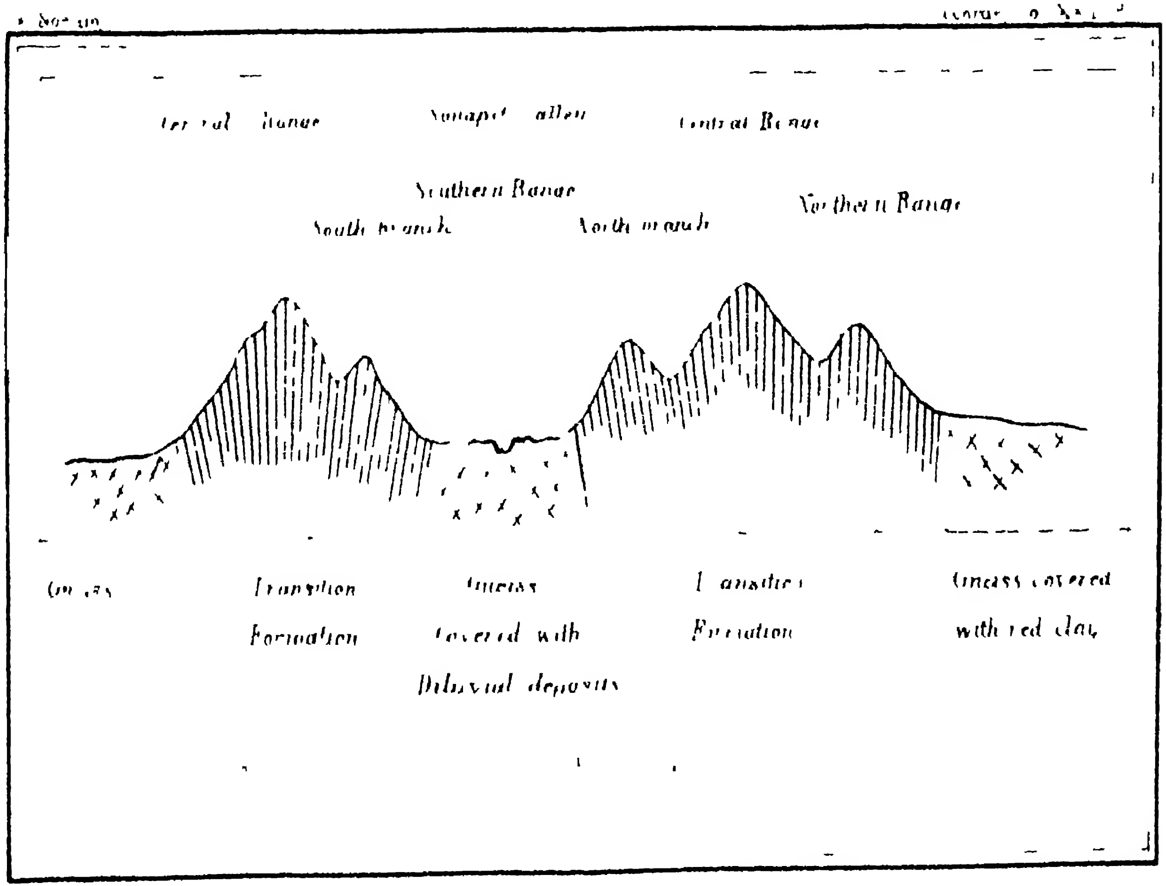
(*b*) *Practical Geology. The gold-bearing deposits.*

As far as I am able to judge from my examinations, it is only the alluvial deposits which contain gold in any quantity to speak of. From the two kinds distinguished above, the red clay is very poor; the result of several hours' washing with about 16 men was a small show of gold. I must mention that I washed at a place which had been pointed out to me as very rich in gold.

Better results are obtained from washing the river deposits for gold; and as these are especially developed in the Sonapet and adjoining valleys, it is to this locality to which particular attention must be drawn. It is, however, very difficult for the present to judge as to the quantity of the gold-bearing sands therein deposited because the actual surface of the rocks is very irregular; the deposits may therefore be thick at one place, while a few yards distant from it they are reduced to a few inches in thickness. But assuming the area over which the gold-bearing alluvial sands are deposited to be 15.3 square miles, and supposing further that the average thickness is not more than 3 feet, the total quantity would amount to 1,280 millions of cubic feet; now, supposing that 40 cubic feet of sand are one ton weight, the total quantity would amount to 32 million tons; supposing that ½ million tons would be washed every day, the probable existing quantity could only be exhausted in 64

[1] Very naturally so, there being little holding ground for such; but it is really not at all so clear that the red clay in the lower grounds may not after all have resulted from the disintegration of the transition rocks forming those hills.—*Ed.*


N
S
Northern Range
Central Range (North branch)
Southern Range (North branch)
R


Southern Range
Transition
Formation
covered with
Diluvial deposits
with red clay

years.[1] In New South Wales the lowest return of gold in one ton has been 4·34 grains; now, supposing that the Sonapet sand contains the same percentage, the annual yield would amount to about 4,500 ounces; even if the quantity is reduced to 2,500 ounces, the yearly profit would be a considerable one.

The Sonapet gold-bearing strata are therefore what is known in the language of the gold-miners as "shallow placers" or shallow diggings, and the stage of exploiting them should therefore be adapted according to this way of occurrence. The hydraulic way would certainly be the best, but I suppose that it will be very expensive.

(c) *The origin of the gold in the Sonapet valley.*—It is a very general belief that gold which is found in alluvial deposits of a stream or river must come from some rich veins, which ought to be found in that part of the country where the stream or river takes its origin. It is true, of course, that the gold must come from somewhere in the upper parts of such a river, but it does not necessarily follow that it comes from rich veins. The gold which is washed out of the sands in the lower part of the river was very likely originally disseminated through thousands of tons of rocks which have been slowly but constantly disintegrated during past ages. The final result of such a long lasting process is a relatively small quantity of refuse in which all the heavy minerals, or those which do not disintegrate easily, have been concentrated amongst them the gold first of all. Therefore strata which, originally poor in gold, can produce deposits comparatively rich in gold but if these have been exhausted, it is of no use to exploit the original matrix.

To confirm the above I quote here such an authority as Lock. In his work "Practical Gold-mining," page 136, he says: "In these shallow diggings nature has for ages been performing the work for which the quartz miner must invent all manner of machinery, and employ a vast amount of capital and skilled labour—the disintegration of the gold-bearing rock and the concentration of the metal, which under its original condition disseminated through quartz and other hard rocks, often in invisible proportions, would have needed vast amounts of capital and much machinery for its elimination, and would in many cases not have repaid the outlay." I think it useful to begin this paragraph with such theoretical explanations, because I am quite sure that a similar way of reasoning will apply in the case of the origin of the Sonapet river gold. I often heard the theory expressed that because there are comparatively rich alluvial deposits in the Sonapet valley there must be rich quartz reefs and veins somewhere in the surrounding hills. This does not follow by any means as the reasoning at the beginning of this paragraph has shown; it is more likely that the gold is disseminated in very small proportions through the metamorphic rocks, and that it has been concentrated in the Sonapet valley which forms a kind of natural basin. It has been concentrated here in the same way as the gold-washer concentrates it artificially in his washing trough, the bulk of the refuse having been washed off.

[1] There is altogether too much assumption and supposition in this estimate. It falls to the ground on the assumption that there can be gold distributed throughout the assumed average thickness of three feet, while it would be absurd to think of running a peopled and cultivated valley through a gold mill for 4·34 grains to the ton of dirt. *Ed.*

Such is my theory about the original matrix of the Sonapet gold; there may be quartz reefs, I will not deny that; but if they do exist, they have still to be discovered. At any rate I have not seen them. I examined a locality which had been pointed out to me as the outcrop of a rich rock, very carefully. Nor did I notice the characteristic and unmistakeable "blue quartz" of the Mysore gold mines. I carefully looked amongst the pebbles in the river-beds for this variety of quartz, but I have never found it; and feel inclined to doubt its existence, although I will not deny it, as the geological conditions are very similar to those of the Mysore mines.

Field notes from the Shan Hills (Upper Burma), by FRITZ NOETLING, PH.D., *Geological Survey of India.*

Echinosphærites limestone.—When I first visited the outskirts of the Shan plateau, east of Mandalay, I was surprised to notice a series of limestones which bore the strongest resemblance to certain limestones of the lower silurian system of Sweden and western Russia. The lithological appearance of some of the beds is striking; like the *echinosphærites* limestone of the Baltic provinces they are of a greenish-grey colour, and even the characteristic rough or, better, honey-combed appearance of the upper surfaces of the beds was not wanting in the limestone of the Shan hills. Other beds consisted of a red ferruginous, shaly limestone which bore the strongest resemblance to the rock forming the boulders of the red *orthoceras* limestone found in the diluvial deposits of northern Germany. I looked however in vain for fossils, and except an indistinct fragment of the stem of a *crinoid*, I could not discover anything else. Now this was certainly not sufficient to arrive at a conclusion as to the age of this limestone series. From a stratigraphical point of view I had however formed the idea that this strata must belong to the palæozoic group, although the actual proof of this theory would have been difficult owing to great dislocations at the western outskirts of the Shan plateau.

I have been more fortunate on a subsequent occasion in my search for fossils, and although the fossils are not particularly well preserved, being very much distorted and crushed they are sufficient evidence to settle the question of the age of this limestone. A little beyond the 24th mile from Mandalay the road cuts through shaly limestone of deep red colour. I found in this limestone numerous fragments of fossils, of which I collected and determined the following species.

Crinoidarum sp. indet. No. 1.—Occurs as stem fragments up to 35 mm. in length and 8 mm. in diameter. It consists of low links of about 1, 5 mm. in height, which are either smooth or show one or two slight ringlike furrows. The round central tube is wide; in one instance where the diameter is 8 mm. the diameter of the central channel is 4 mm.

Crinoidarum sp. indet. No. 2.—The links of the stem are similar in appearance to those of No. 1; but instead of being perforated in the centre by a wide round channel they are perforated by a narrow channel in the form of a five-rayed star.

Both specimens are very common either in isolated links or fragments of the stem, but it is only on the weathered surfaces of the beds that they can be well seen.

Echinosphærites Kingi sp. nov.—A gigantic species of this well-known genus; one of the specimens measures 160 mm. in diameter, and allowing for the distortion which the specimen had undergone, it certainly must have measured originally not less than 80 mm. in diameter. The irregularly polygonal plates and their furrowed surface can be well seen, so that there can be no doubt about the identity of this huge species.

Orthoceras sp. indet.—Fragments of an *orthoceras* belonging to the group of the "regulares" are common though much crushed. The chambers are low and numerous; I counted 17 in a fragment of 35 mm. The sipho lies central. The species reached a considerable length as the fragments preserved prove, but better material is wanted to make out the species. These few fossils, however few in number and fragmentary they are, prove certainly the lower silurian age of the red and greenish-grey coloured limestone. The presence of such a characteristic form as an *echinosphærites* even permits the identification of the exact horizon of the red limestone: it is an equivalent of the *echinosphærites* limestone of the Baltic provinces. It not only contains the same fossils but also strongly resembles the latter lithologically. How can we account for such a strange phenomenon as this? We find here a fauna under 22° northern latitude which is precisely the same as found in the Baltic provinces (59° to 60° N. Lat.), whilst the silurian fauna of the Himalayas approaches much closer to the silurians of Central Europe. The fauna of the lower silurians of the Himalayas is as different to that of the Shan hills than is the silurian fauna of Bohemia to that of England. It must therefore be assumed that a branch of the Arctic province of the ocean by which the lower silurian beds were deposited reached at least to 22° N. Lat. of the Indo-Chinese peninsula; it is even likely that it extended still further to the south as the limestone beds of the Shan hills are again met with in Tenasserim. I hope that on my return march I shall be able to collect some more fossils from this interesting locality.

March 20th, 1890.

A description *of some* new species of *Syringosphæridæ, with* remarks upon their structures, &c., *by* Professor P. MARTIN DUNCAN, M. B., London, F.R.S., etc. (With three plates.)

CONTENTS.

I.—INTRODUCTION.

I. The Karakoram stones, the *Syringosphæridæ nobis*, were somewhat fully described by me in 1878 and the specimens which I had then the advantage of studying were in fairly good condition. The fossils formed part of the collection of the late F. Stoliczka, Palæontologist to the Yarkand Mission, and indeed were obtained by him shortly before his death, from triassic strata in the Karakoram range.

The collection was forwarded to me for description by the then Director of the Geological Survey of India, H. B. Medlicott, Esq., F.R.S., through Dr. W. T. Blanford, F.R.S. It was understood that the descriptions and plates should form part of a volume of the Scientific Results of the second Yarkand Mission to be published by the Indian Government as a kind of memorial to F. Stoliczka. The work appeared in 1879.

A collection of the fossils and several sections of them which had been studied and drawn were placed in the National Collection in England. After I had described the *Syringosphæridæ*, I found to my considerable annoyance that I had not had all the collection sent to me from Calcutta; but Dr. Blanford was good enough to interest himself in the matter, and I was promised the rest of the specimens. They arrived after an interval of some years and this communication is the result of their study.

In the interval, some opinions regarding the affinities of the *Syringosphæridæ* had been promulgated and they were asserted by some of that modern school which criticises and does no original work, to belong to the *Parkeriæ* of Carpenter and Brady. Both were spheroidal and had tubes inside and nodules outside, and therefore they must be the same. At that time I had specimens of calcareous *Parkeriæ* and it had been shown by Carter that the original condition of *Parkeriæ* was not "arenaceous," so it was possible to compare the *Syringosphæridæ* with the gigantic *Parkeriæ*. As in the genus *Stoliczkaria* nob. there are no internal spaces which are so characteristic of *Parkeria* and as in species of *Syringosphæria* the number and distribution of spaces varies greatly, I began by comparing *Stoliczkaria* with

Parkeria and the communication to the Geological Society (Quart. Journal, Geological Society, Vol. xxxviii, 1882, p. 69), explained the distinctness of the two groups.

One good came out of this unnecessary work, and it was the proof that in one or two of the figures given in the Memoir on *Syringosphæridæ*, the intertube structure had been called tube. The error made no difference to the correctness of the specific diagnoses, and it is interesting to know that in the specimens lately examined, my very able artist decided that in places it was impossible to say what was tube and what was intertube.

In January 1888, I learned to my great surprise that specimens of the group had been sent by Mr. Medlicott to Dr. H. A. Nicholson, and that this very hard-working palæontologist was about to publish proofs that the *Syringosphæridæ* were *Hydrocorallines*, and that he could show structures which certainly I had not seen or figured. The specimens could not have fallen into better hands than those of my friend, but it would have been better had I been informed of the fact, as it will be necessary now for me to show that Dr. Nicholson might have received some, I trust, satisfactory enlightenment from me.

However, the wished for specimens came at last, and I have to thank Dr. Woodward, F.R.S., of the British Museum, for having the requisite thin sections cut and the able lapidary of the Museum, for the pains he took with the specimens.

The examination of the new specimens brings to light two new species of *Syringosphæria*, and specimens of two established species.

The structural details are often beautifully seen in the sections, and all the statements I made regarding the nature of the cones of tubes and the inter-cone structures, of the tubes themselves and the intertube, and of the spaces and pores, in the Results of the Yarkand Mission, 1889, hold good. There is little to add regarding the morphological elements of the forms, although the arrangement of them varies interestingly. One species, *Syringosphæria medlicotti*, links *Stoliczkaria* to *Syringosphæria* more than any other, for the pores and spaces are exceedingly few in number and the conical masses of radiating tubes are well defined.

As the occasion has not yet arisen, it is not necessary to do more in this communication than describe the new species; but before passing on, it is advisable to refer to a statement involving the genus *Heterastridium*, Reuss.

II.—On the so-called genus, Heterastridium, A. E. von Reuss, 1865.

The late Prof. A. E. von Reuss was a very accomplished palæontologist, and the numerous species of *Madreporaria*, *Foraminifera*, and *Bryozoa*, which were studied by him, were most carefully described and delineated. He was a truly scientific worker. Probably no one had a greater knowledge of the mesozoic and tertiary *Madreporaria* than my friend, and I venture to say that he was much more likely to recognise a *Madreporid* than some British palæontologists who, whilst distinguished as critics, have never done any original work in the group. I had that belief in von Reuss' powers that I did not hesitate to admit *Heterastridium* as one of the group in which Reuss placed it, and I shall require some very definite proofs before I believe that the genus refers to the *Syringosphæridæ* (*nobis*).

Heterastridium was described by von Reuss in Sitzungsb. d. Wien. Akad. 1865, Bd. 51, p. 385, Pl. I-III, the title of the communication was "Zwei neue *Anthozoen* aus den Hallstädter Schichten."

On p. 390 of this work, Reuss wrote that the forms belonged without doubt ("Keinem Zweifel") to the division of *Madreporaria with perforated walls.* He observed that the presence of spongy cœnenchyma distinguishes the forms from the *Poritidæ* and approaches them to *Madrepora.* He remarked, "I give the genus on account of the existence of distinct calices (sternzellen) and of tube cavities, the name of *Heterastridium*."

It is now published, by the latest author upon systematic palæontology—"In 1865 Prof. Reuss published descriptions and figures of some fossils from the Alpine trias, for which he had proposed the generic name of *Heterastridium*. It is clear from these that *Heterastridium* is very closely allied to *Stoliczkaria*, if not absolutely identical with it. In case of the identity of these two genera being established, the name of *Stoliczkaria* will have to be abandoned in favour of that of *Heterastridium*, the latter having been published first." (A Manual of Palæontology by Nicholson and Lydekker, 1889, V. I., p. 227, foot-note.)

Now I beg to differ from Dr. Nicholson, who informed palæontologists in January 1888, in the Annals and Magazine of Natural History, that he was about to prove that the *Syringosphæridæ* belonged to the *Hydrocorallinæ* of Moseley, and who in the interval—for the proofs have not come to light--publishes the foot-note copied above.

As Dr. Nicholson will publish his proofs, I must wait before replying to his statement that the *Syringosphæridæ* are *Hydrocorallinæ*; but the dictum regarding the possible alteration of the name of the genus I named after F. Stoliczka, may be answered and contradicted at once.

Firstly, Dr. Nicholson has unfortunately mistaken the characters of the genus *Stoliczkaria*, Dunc. (Sci. results of the second mission to Yarkand, *Syringosphæridæ*, 1879, p. II.) Amongst other characters there given, is the negative one, which gives the generic stamp "*No pores exist.*" Dr. Nicholson has figured a section which he considers to illustrate the minute structure of *Stoliczkaria, op. cit.*, p. 228, fig. 113, B. and *the pores (spaces) are seen in vertical section.* It is not a section of a *Stoliczkaria.* The figure given by the same able author, in illustration of the shape and surface of *Stoliczkaria granulata*, Dunc. on his p. 228, fig. 112, is not of the species or genus, but is clearly my *Syringosphæria porosa*; the section I have criticised is also a part of a *Syringosphæria.*

The reticulate *columella* of Dr. Nicholson is a tubular mass which opens out at the bottom of a superficial pore—see the structure illustrated in this communication, Pl. fig. 3; it in no way represents the *columella* of a *Hydrocoralline.*

Having shown that the genus *Stoliczkaria,* which has no spaces or pores inside and outside, cannot be the same as *Heterastridium* which has them, it is necessary to say a few words upon the rules of zoological nomenclature in regard to the value of "priority."

It is the result of careful and judicious consideration that permits an author who has diagnosed a genus correctly, and who has so described its structures and characters that the genus can be recognised, to have the generic name which he gave recognised and perpetuated.

Heterastridium, Reuss, 1865, has the structures and characters of a perforate *Madreporarian*; there are none of the structural and distinctive characters of any genus of *Syringospharidæ* in Reuss' descriptions. No one would recognise a *Syringosphærid* from the description. I therefore decline to admit the priority of my late and much esteemed friend von Reuss in this matter, and, on the contrary, I claim that if *Heterastridium* should turn out to belong to one of the genera I described in 1879, it will have to merge into it.

It is perfectly evident after the study of the specimens now brought before the notice of palæontologists for the first time, that they are of the same tubular character as those already described, and that they present none of the essential arrangements of structures characteristic of *Hydrocorallinæ*.

III.—LIST OF THE SPECIES DESCRIBED AND FROM THE COLLECTION NOW UNDER CONSIDERATION.

Syringosphæria medlicotti, sp. nov., Plate I & II.
" *intermedia*, sp. nov. " III
" *plana*, Dunc. variety.
" *monticularia*, Dunc. var *aspera*.

IV.—DESCRIPTION OF NEW SPECIES OF *Syringosphæria*.

The most important of the new species of *Syringosphæria* is *Syringosphæria medlicotti*, and the type specimen is so well preserved, both externally and within, that it would have been very acceptable had it come to hand during the examination of the forms which were described for the work on the second Yarkand Mission. The difficulty of understanding the internal construction of the species which were first described, was considerable, on account of the liability of confounding the tube structure with the intertube material. That this was done in more than one instance there is no doubt. But in the instance of the specimens of the new species the mistake cannot be made, and the distinctness of the structures is evident. Nevertheless there is, at one spot of a piece of the type of the new species, a condition of the intertube material which simulates the tube structure in a very interesting manner and the intertube seems to be, but is not, hollow.

Sections of the type were made at the British Museum, and some were tangential so as to cut across the series of conical masses of radiating tubes not very far from the surface of the body; others were equatorial, and in parts of them the radiating cones were of course cut longitudinally.

The species has the generic characters well maintained and the tubes are in many series of cones, with the bases external, all radiating from the centre of the body; each tube varies in length, is subject to twist and to depart from the radial course for a certain distance and to return, to bifurcate, to become moniliform, and to unite by offshoots with neighbouring tubes; but the diameter varies very slightly. The lumen of each tube is separated from those of its fellows by a space which is rarely greater than one half of the tube's diameter, and this intertube is occupied by a calcite which is differently coloured, as a rule, from that which fills the tubes. Again, each system or cone of tubes is separated from its neighbours by a greater or less thickness of irregularly disposed tubes, which are usually smaller than those of

the cones and they have very thin intertube structure. This intercone structure is often quite without definite histological elements, but occasionally the tubes of it are filled with a dark opaque substance and then become visible. The cones terminate at the surface of the body in conical elevations, and also in small warty bodies. Few "pores" with tube endings on their floors exist on the surface of the body and they are to be seen within it also The arrangements and combinations of these structures determine species.

Syringosphæria medlicotti, sp. nov. Plates I and II, figs 1—11.

The body is moderate in size, sphæroidal, or it may be longer than broad and broader than high; the sides are symmetrical. Externally the body is covered with small, broad-based, low, conical projections, either slightly compressed laterally at the top or nodular there; they are somewhat variable in size, and have their circular bases rather close. Numerous small warty projections are placed between and upon the flanks of the cones. Spaces or pores are very few and small, somewhat irregular in shape, often at the base of a wart and more or less overhung by it, or upon the flank of a conical prominence.

Height of body 34 and 37 mm., breadth 43 and 47 mm. About three cones and their interspaces occupy 4 to 7 mm. Common breadth of a cone 2 to 5mm.; height 1 to 5mm.

The surface of these external structures is crowded with the endings of radially disposed, obliquely placed and even gyrose, tube endings, separated by narrow intertube structure, very irregular in places and often incomplete, more or less projecting and often granular. The regularity of the shape and position of the tube endings is considerable upon the conical projections, and the intertube material often presents a radiating direction from the top of the projection cross bars also limiting the tubes. The running of the tubes in direction more or less parallel to the surface before turning directly outwards, complicates the appearance.

Tubes open in a similar manner on the warts, and where a space or pore can be well seen, its boundary is of tubules. Between the conical projections is the outer or superficial termination of the intercone structure, it is less regular as a rule than that of the cones, and is often small and confused; but it is to be remarked that there is not always an histological distinction to be made between the intercone structures internally as at the surface of the body.

Internally, the tangential sections show numerous small, separate systems of tubes, variable in diameter, separated by narrow intercone structure; or the arrangement may be slightly confused by the tubes of warts and the presence of spaces. The lumen of a tube is usually of greater diameter than the breadth of its limiting intertube structure, is rarely perfectly circular, and is largest in the tubes remote from the axis of a cone. There is some symmetry of the linear and radiating series of tube openings, bounded by distinct radiating lines of intertube and crossed by others. Each system of tubes which finally ends in a conical projection, is fairly separated from its fellows. The intercone structure is usually confused. The spaces show a line of intertube structure more or less around them, and tubes entering their floors. The diameter of the tubes of the cones is from 1-330 to 1-500 inch; some close to the axis are 1-1,000 inch, and this is the usual diameter of the intercone tubes or even less in places, 1-2,000 inch.

Radial sections of the body show the systems of cones narrow at the centre enlarging towards the periphery and ending in surface cones and warts. The tubes are fairly straight for some distances, but dip away suddenly, a crossing line of intertube being then seen, or they bifurcate or send off a junction tube. Near the edge of the section the tubes are often filled with opaque material, and then their closeness, moniliform shape, junctions and twistings may be appreciated.

The intercone material is also very indefinite longitudinally. The spaces are often very long, and the lateral limitation by intertube calcite and the entry of tubes centre-wards and the exit of others towards the peripheral end, are well seen.

The intertube structure seems to have a portion near to one tube more or less separate from the portion close to the next tube. Sometimes a definite line occurs there and usually an indefinite, ragged, dark tint denotes the position of possible separation. Some of the intertube structure crosses the tubes at right angles, but much of that appearance is produced by the cleavage of the calcite of the tube.

Syringosphæria intermedia, sp. nov. Plate III, figs. 12—18.

The body is rather large, depressed, and ellipsoidal in vertical, and circular or ellipsoidal in equatorial section; broader than high, very symmetrical. Height of type 36mm., breadth 43mm., length 60mm. Another specimen is 44mm. in height, but the body is more circular in marginal outline and the length is 53mm.

The surface has rather wide apart, irregularly spaced, small, low, bluntly conical, more or less deformed tubercles, varying in size. In the interspaces are greatly crowded, very small, warty prominences, amongst which are very few irregularly-shaped, small pores, except in one or two places where they are numerous; the pores may also be at the sides of the bases of warts and upon the flanks of tubercles.

The usual reticulation of tubes and intertube structure occurs.

The pores may or may not have a raised rim around them consisting of intertube calcite. Tube ends may be seen on the floors of some pores, as in pl. I, fig. 3.

Sections show the generic characters very well, and also that the radiating conical series of tubes, the tube systems, although mostly very large, are unequal, and that there are small tube systems especially in the confused intercone structure. These mostly refer to the tubes of wart-like projections. The warts in section, below the surface, present all the structural characters of the tubercles, and are small, crowded, or not, with tubes and intertube structure. The number of the tubes varies with the diameter of the wart, and there may be many or merely three or four tubes to a wart. There is much difficulty in distinguishing between tube and intertube structure, for this last is sometimes stout and coloured like a filled-up tube: but usually the tubes are larger than the intertube structure. The tubes, even close to the surface of the body, are not constantly radial in direction, and there is much bending, joining, sudden return to the radial direction and geniculation. The pores appear as vacant spaces in tangential and longitudinal sections of the body; they are more numerous than their external distribution would lead one to believe. They are more or less circular or deformed in outline in the tangential sections, and they are narrow and elongate in the radial sections. (Plate III, figs. 13 and 15.) A pore is thus a chamber in the body more or less cylindrical in shape. The diameter of a pore (in section) is from a quarter to one half of a millimetre, the height of a chamber may be 1mm. The sections prove that the chambers are in the midst of

the tubes of the body and are vacant spots. The tubes enter the base or proximal end of a chamber and may be three, four or five in number, and their intertube material suddenly ceases. The sides of the chamber are limited by tubes. Distally, the space is covered with a thin layer of intertube, and tubes start on their way to the superficies from that structure. At one spot close to the surface of a body (Plate III, fig. 18), the dark infilling of some tubes has entered a chamber, and there are slender offshoots to be seen from the tubes on either side to the space or chamber; tubes pass off distally towards the superficies.

The intercone structure is very confused.

Diameter of base of a tubercle, 1 to 2mm., some in transverse section 3mm. Height of tubercles 2·5 to 5 mm. The warts 2·5mm. broad. Distance of tubercles variable from 2 to 5mm.

Syringosphæria plana, Dunc. Sci. Res. Sec. Yarkand Mission, 1879, p. 14. This species is represented in the collection lately sent to the British Museum, and the specimens have an oblately spheroidal shape, and the surface of the body is nearly smooth, there being some few low, rounded off tubercles and numerous granules: the pores are small and scattered. In sections it is noticed that the conical systems of tubes are few and large: in some cases they are well defined at their circumference, but in others they merge into a confused intercone structure. The tubulation of the cones is large, coarse, and close. The spaces are fairly numerous, and are placed without order in any position. As the best specimen has decidedly more tubercles upon it than the type, I have placed it as a variety.

S. plana, *Var.* with several tubercles.

Syringosphæria monticularia, Dunc. Var. *aspera*. Duncan, *op. cit.*, p. 13, 1879.

This interesting variation of the species, *S. monticularia*, is represented in the collection by a small specimen. The microscopical characters are exceedingly well shown, and the number of small cone-systems crowded together is remarkable. Each system is small, and relates to a wart at the surface, the number of tubes in it is small. The larger cone systems correspond with superficial tubercles. In one of the longitudinal sections the tubes are wonderfully distinct and wavy, geniculate, straight for a little distance and bent; they evidently have a true wall as was noticed by me in the case of other specimens. Having examined a considerable number of specimens in sections, it appears that the body of a *Syringosphærid* is composed of tubes with walls of varying thickness which fuse and produce intertube structure; or which do not fuse and then bound spaces.

V.—DESCRIPTIONS OF THE PLATES.

Plate I.

Figure 1. *Syringosphæria medlicotti*, sp. nov.
View of the exterior, showing the surface endings of cones and warts (placed within an ellipse denoting the size and shape of the body). Central figure, mag. 3.

" 2. Same species. A view of the outer surface of a cone showing the circular and elongate and deformed openings of the tubes, separated by projecting intertube material. Mag. 20.

11

17

18

igure 3. Same species. Surface of body showing a pore, or space; it is surrounded by tubes, and tubes open on its floor. Mag. 75.

„ 4. Same species, a tangential section, thin, showing sections of tube-systems, or cones cut across (the smallest system is that of a "wart"); the intercone or inter-system, badly differentiated, surrounding space is seen. The three vacant spaces are "spaces," and would be pores at the surface. Mag. 15.

„ 5. Same species. A pore and its surrounding tube matter, many tubes cut across, some circular and others elongate. Tangential section. Mag. 75. (The lumen of a tube is light in tint.)

„ 6. Same species, tangential section near the surface and reaching it. The tubes are filled with dark matter, and the intertube matter is lighter in tint. The opening of the tubes at the surface is seen, and also the irregular mesh-like structure of the intercone structure. Mag. 75

Plate II.

Syringosphæria medlicotti.

Figure 7. A longitudinal view of part of a cone or tube-system, and a portion of an intercone. The tube structure is light in tint and the calcareous intertube material is dark. The cross bars refer to sudden bendings of the tubes. Mag. 75.

„ 8. Same species. Longitudinal view of a part similar to figure 9. The tube part is lightest in tint.

„ 9. Same species. Tubes and intertube structure cut across The dark lines in the intertube when seen in longitudinal section simulate internal hollows. Mag. 250.

„ 10. Same species. A longitudinal view of a space or pore, surrounded by tubes and intertube. Mag. 75.

„ 11. Same species. A thin section made at the base of a mamelon or outside cone; the irregular shape of the tubes seen cut across, is shown and they are light in tint.

Plate III.

Syringosphæria intermedia, sp. nov.

Figure 12. The surface slightly magnified, showing the numerous warts and few cones; the ellipse indicates the shape and size of the body.

„ 13. Same species. A transverse section of a cone system with a space or pore central. Mag. 75.

„ 14. Same species. A tangential section, near the base of cones, the dense intertube is dark, the small tubulation (cut across) is light: a space or pore is filled with dark matter, and the intercone space is indistinct and dark. Mag. 50.

„ 15. Same species. A longitudinal section showing the long, narrow deformed spaces or pores, surrounded with tubes and intertube. Mag. 20.

„ 16. Same species. Tubes filled with dark matter near the surface of the body, in longitudinal section. Mag. 50.

List of assays and examinations made in the Laboratory, Geological Survey of India, during the months of February, March, and April 1890—continued.

<table>
<tr><th>Substance</th><th>For whom</th><th>Result.</th></tr>
<tr><td>Coal, from Darjeeling</td><td>P. N. Bose, Geological Survey of India</td><td>
<table>
<tr><th></th><th>Pit No 3 Lisu Valley.</th><th>Pit No. 7, Chhurhauti Valley, depth 9 feet.</th><th>Pit No 25, Chunkhola or Ramtek Jhora, depth 7 feet.</th></tr>
<tr><td>Moisture</td><td>14·54</td><td>4·21</td><td>16·10</td></tr>
<tr><td>Volatile matter</td><td>8·86</td><td>14·09</td><td>15·47</td></tr>
<tr><td>Fixed carbon</td><td>63·96</td><td>62·56</td><td>51·85</td></tr>
<tr><td>Ash</td><td>12·64</td><td>19·14</td><td>16·58</td></tr>
<tr><td></td><td>100·00</td><td>100·00</td><td>100·00</td></tr>
<tr><td></td><td>Ash - grey, cakes strongly and forms a light tumid coke</td><td>Ash—pale brown, cakes strongly.</td><td>Ash—reddish gray, cakes strongly</td></tr>
</table>
</td></tr>
<tr><td>Minerals sent for determination.</td><td>Sir Alexander Wilson, Calcutta</td><td>A = Quartz stained with iron.
B = Crystals of iron pyrites changing into limonite.
C = Argentiferous galena.</td></tr>
<tr><td>Coal, from No. 2 borings at Jamgram, Raniganj Coal-field.</td><td>Kilburn & Co., Calcutta</td><td></td></tr>
<tr><td>Specimens of clay from Warora and Wardha.</td><td>G. B. Reynolds, Warora, C. P.</td><td>Only one out of the three samples received, stood the test required for firebricks.</td></tr>
<tr><td>"Supposed matrix of the diamond from Wajra Karur, Madras.</td><td>Geological Survey of India</td><td>Contains:—
SiO_2 . . . . . . 44·73
Fe_2O_3 . . . . . . 4·42
Al_2O_3 . . . . . . 12·83
CaO . . . . . . 10·35
MgO . . . . . . 15·99
CO_2 . . . . . . 2·85
H_2O (combined) . . . 9·07
100·24</td></tr>
<tr><td>Two samples of quartz for gold, iron pyrites, and pyrolusite.</td><td>Mackillican & Co., Calcutta.</td><td></td></tr>
<tr><td>Coal, from Northern Shan States, Burma.</td><td>The Financial Commissioner, Burma.</td><td>Moisture . . . . . 21·30
Volatile matter . . . 33·18
Fixed carbon . . . 33·06
Ash . . . . . . 12·46
100·00
Does not cake Ash—dark-red</td></tr>
</table>

List of assays and examinations made in the Laboratory, Geological Survey of India, during the months of February, March, and April 1890— concluded.

Substance	For whom	Result	
Coke, made from coal from the Lisu Valley, Darjeeling.	P. N Bose, Geological Survey of India	Moisture .	2 59
		Volatile matter . .	2 43
		Fixed carbon . . .	67 78
		Ash . . .	27 20
			100 00
		Sulphur, present as sulphide .	58%
		" " sulphate . .	04%
Quartz for gold, from Sonapet	G. T. Peppe, Ranchi		
Mineral from Jabalpur sent for determination	Burn & Co, Calcutta	Scolecite	
Mud, for gold . .	Mackillican & Co, Calcutta		
Minerals, supposed to contain copper from the Wainganga, for determination.	C W McMinn Deputy Commissioner, Chanda District, Central Provinces	Specimen No. 1 —oxide and carbonate of iron, no copper Specimen Nos 2 to 4,—epidote, no copper	

Notifications by the Government of India during the months of February, March, and April 1890, published in the "Gazette of India," Part I.—Appointment, Confirmation, Promotion, and Retirement.

Department	Number of order and date	Name of Officer	From	To	Nature of Appointment, &c	With effect from	Remarks
		None					

Notifications by the Government of India during the months of February, March, and April 1890, published in the "Gazette of India," Part I. —Leave.

Department.	Number of order and date.	Name of Officer	Nature of Leave	With effect from	Date of Return	Remarks
Revenue and Agricultural Department	95/93 8S, dated 25th Apl 1890.	Theo. W. H Hughes	Special leave	Date of availing himself of it		

Annual Increments to Graded Officers, sanctioned by the Government of India during February, March, and April 1890.

Name of Officer.	From	To	With effect from	Number and date of sanction.	Remarks.
None.					

Postal and Telegraphic Addresses of Officers.

Name of Officer	Postal Address.	Nearest Telegraph Office
R. Bruce Foote . . .	Anantapur . . .	Anantapur.
T. W. H. Hughes . . .	Calcutta	Park Street, Calcutta.
C. L. Griesbach . . .	Calcutta	Park Street, Calcutta.
R. D. Oldham	Quetta (Baluchistan) .	Quetta.
P. N. Bose	Pillan's Hat . . .	Siliguri
T. H. D. LaTouche . . .	Calcutta . .	Park Street, Calcutta.
C. S. Middlemiss . . .	Khushab	Khushab
P. Lake	Calcutta	Park Street, Calcutta.
P. N. Datta	Khewra (Jhelum) . .	Khewra.
F. Noetling	Lashio (Shan States) .	
Kishen Singh	Quetta (Baluchistan) .	Quetta.
Hira Lall	Ditto . . .	Ditto.

ADDITIONS TO THE MUSEUM.

None

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FROM 1ST JANUARY TO 31ST MARCH 1890

Titles of Books — *Donors*

ALLEN, *Alfred H.*—Commercial Organic Analysis: a treatise on the properties, proximate analytical examination, and modes of assaying the various organic chemicals and products employed in the arts, manufactures, medicine, &c., with concise methods for the detection and determination of their impurities, adulterations, and products of decomposition. 2nd edition. Vol III, pt 1. 8° London, 1889.

BLOXAM, *Charles Loudon*.—Metals, their properties and treatment. Partially re-written and augmented by Alfred K. Huntington. New edition. 8° London, 1885.

BRONN'S Klassen und Ordnungen des Thier-Reichs. Band II, Abth. III, lief 5-6, Band V, Abth. II, lief 25-27. 8° Leipzig, 1889.*

BROWN, *Robert*.—Our Earth and its Story: a popular treatise on physical geography. 2 vols. 4° London, 1887-1888.

CLARKE, *F. W.*—The meteorite collection in the U. S. National Museum: a catalogue of meteorites represented Nov. 1st, 1886. 8° Pam. Washington, 1889. — THE AUTHOR.

CROLL, *James*.—Stellar Evolution and its relations to geological time. 8° London, 1889.

DAWSON, *Sir J. William*.—New species of Fossil Sponges from the Siluro-Cambrian at Little Metis, on the Lower St. Lawrence. With notes by Dr. G. J. Hinde. 4° Pam. Montreal, 1889. — THE AUTHOR.

DAWSON, *Sir J. William*.—On fossil plants from the Mackenzie and Bow rivers. 4° Pam. Montreal, 1889. — THE AUTHOR.

DE LA NOË, *G.* and DE MARGERIE, *Emm.*—Les formes du Terrain. 4° Paris, 1888.

EISSLER, *M.*—The metallurgy of Gold: a practical treatise on the metallurgical treatment of gold-bearing ores, including the processes of concentration and chlorination, and the assaying, melting, and refining of gold. 2nd edition. 8° London, 1889.

EISSLER, *M.*—The metallurgy of Silver: a practical treatise on the amalgamation, roasting, and lixiviation of silver ores, including the assaying, melting, and refining of silver bullion. 8° London, 1889.

EVERETT, *J. D.*—Units and Physical Constants. 2nd edition. 8° London, 1886.

FLETCHER, *L.*—On the meteorites which have been found in the desert of Atacama and its neighbourhood. 8° Pam. London, 1889. — THE AUTHOR.

FLETCHER, *L.*—On the supposed fall of a meteoric stone at Chartres, Eure-et-Loir, France, in September 1810. 8° Pam. London, 1889. — THE AUTHOR.

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FRESHFIELD, *Douglas W.* and WHARTON, *W. J. L.*—Hints to Travellers, scientific and general. Edited for the Council of the Royal Geographical Society. 6th edition, revised and enlarged. 8° London, 1889.

FRITSCH, *Karl v.*—Allgemeine Geologie. 8° Stuttgart, 1888.

HAIDINGER, *Wilhelm Karl Ritter von.*—Handbuch der bestimmenden Mineralogie. 8° Wien, 1865.

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LEWIS, *T. R.*—In Memoriam. Physiological and Pathological Researches: being a reprint of the principal scientific writings of the late T. R. Lewis. Arranged and edited by Sir William Aitken, G. E. Dobson, and A. E. Brown. 8° London, 1888. LEWIS MEMORIAL COMMITTEE.

MARTIN, *K.* and WICHMANN, *A.*—Beiträge zur Geologie Ost-Asiens und Australiens. No. 20. 8° Leiden, 1890.

MURRAY, *James A. H.*—A new English Dictionary on historical principles; founded mainly on the materials collected by the Philological Society. Part V. 4° Oxford, 1889.

Paléontologie Française. 1^re^ série, Animaux Invertébrés, Éocène Échinides, Tome II, livr. 18: 2^me^ série, Végétaux, Éphédrées, livr. 41. 8° Paris, 1889.

PARKINSON, *S.*—A treatise on Optics. 4th edition. 8° London, 1884.

SORLEY, *W. R.*—Mining Royalties and their effect on the iron and coal trades. Report of an enquiry made for the Toynbee Trustees. 8° London, 1889.

STOKES, *George Gabriel.*—On light. 8° London, 1887.

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Abercromby, The Hon. Ralph.	Russell, The Hon. F. A. Rollo.
Archibald, E. Douglas.	Scott, R. H.
Bonney, Prof. T. G.	Stokes, Prof. G. G.
Evans, (the late) Sir F. J.	Strachey, Lt.-General.
Geikie, Dr. A.	Symons, G. J., Chairman.
Judd, Prof. J. W.	Wharton, Capt. W. J. L.
Lockyer, J. Norman.	4° London, 1888

THOMSON, *Sir C. Wyville*, and MURRAY, *John.*—Report on the scientific results of the voyage of H. M. S. "Challenger," during the years 1873—76. Vol. II, Physics and Chemistry; and Vol. XXXII, Zoology. 4° London, 1889 REV. AND AGRI. DEPARTMENT.

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WATT, *George.*—A Dictionary of the Economic Products of India. Vols. I-II. 8° Calcutta, 1889. GOVT. OF INDIA.

WRIGHT, *Charles R. Alder.*—Metals and their chief industrial applications. 8° London, 1878.

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BURMA.—Report on the administration of Burma during 1888-89. Flsc. Rangoon, 1889.
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RECORDS

OF

THE GEOLOGICAL SURVEY OF INDIA.

Part 3.] 1890. **[August.**

Report *on the* Geology *and* Economic Resources *of the* Country adjoining the Sind-Pishin Railway between Sharigh and Spintangi, *and of the* Country between it and Khattan, *by* R. D. OLDHAM, *Deputy Superintendent, Geological Survey of India.* (With a map.)

I.—STRATIGRAPHY

The area to be described in the following report consists of the country adjoining the Sind-Pishin Railway between Sharigh and Spintangi, together with the country extending eastward from Spintangi to Khattan. Of that portion which lies near the railway no previous accounts appear to have been published, except the cursory description by Dr Blanford,[1] and a brief report by Mr. R. A. Townsend,[2] of Khattan itself Mr Townsend has written an excellent account,[3] published in the Records of the Geological Survey.

Area described.

The oldest rocks seen are exposed close to the road from Harnai to Loralai, about eight miles from the former place. Here the gorge of the Mirib opens out into an amphitheatre some four miles long by two miles broad, surrounded on all sides by precipitous scarps of limestone. In the centre of this amphitheatre there rises a sharply folded anticlinal hill of compact grey unfossiliferous limestone. The same limestone is seen in the Tarai Tangi, further eastwards, but nothing is known of its lower limit or thickness.

Oldest rocks seen, Nummulitic.

The next beds, in ascending order, are green and grey shales, occasionally impregnated with organic matter, at the top of which come some hundred feet of purple and green shales and shaly limestones. One band of bright purplish red limestone about 10 or 15 feet thick, is very conspicuous and its outcrop can be traced right round the amphitheatre, with this exception, the colours are not confined to particular beds, but bands of purplish colour ramify through the rock, passing irregularly through its mass irrespective

Chappar shales.

[1] Mem Geol Surv Ind., XX, 86—93 (1883)
[2] Proc Govt Ind. P W D, November 1884
[3] Rec. Geol Surv. Ind XIX, 204—210 (1886)

of the original bedding. These beds are precisely similar, in lithological characters and in stratigraphical relations, to those exposed in the centre of the Chappar rift, and they may with advantage be distinguished as the Chappar shales.

Evidence of volcanic activity.

Although these beds do not contain any beds of purely volcanic origin, whether trap or ash, either in the Míráb Tangi or in the Tarai Tangi, yet there are distinct traces of contemporaneous volcanic activity in the shape of small rounded granules of glassy quartz, angular scales of mica and, in some beds, a distinct proportion of fine volcanic ash mixed with the sediment of which they are composed.

Thickness.

No recognizable fossils were found in this group, but organic matter is not uncommon, either as compressed fragmentary plant remains or as a structureless impregnation of the general body of the rock. The thickness, which was not estimated with any degree of accuracy, is about 600 to 700 feet.

Dunghan limestone.

Above these shales come compact bedded blue or dark grey limestones, generally unfossiliferous in the lower portion but the upper beds contain numerous fossils which, as a rule, are only seen in section; among them *nummulites* occur in considerable abundance. I propose to call this series of beds the Dunghan group, or Dunghan limestone, from the high hill, east of Spintangi, of which it forms the greater portion, if not the whole.

Pseudo-conglomerate.

Near the top of this group a peculiar form of limestone occurs, called a "marine conglomerate," by Mr. Townsend [1] and a "limestone breccia" by Dr. Blanford; [2] the latter observer describes it as consisting of "dark-grey angular limestone fragments in a somewhat paler limestone matrix. Both fragments and matrix contain small *nummulites*, and sometimes *alveolinæ*, and no constant difference has been traced between the forms found in the two portions of the rock." The resemblance of this rock to a conglomerate or breccia, composed of fragments ranging to several inches in diameter, is often very striking and it is, at times, almost impossible not to accept it as of clastic origin. But the local occurrence of this structure, the absence of any trace of such violent clastic action in the associated beds, the absence of any apparent distinction between the fauna of the matrix and of the fragments, and the fact that there is every gradation from a mere mottled limestone to the most conglomerate-like variety, all point to the conclusion that the structure is in reality of concretionary origin.

Thickness.

The total thickness of the limestone cannot be measured with accuracy, but three independent estimates were formed which gave fairly concordant results varying from 1,500 to 1,800 feet. The highest of these estimates is, I believe, the most accurate, and practically the whole of this great thickness consists of limestone, varying in its degree of purity, but with no noticeable bands of shale.

Dunghan group at Khattan.

At Khattan pseudo-conglomerate and overlying flaggy limestone are found, precisely similar to those of the Harnai valley, and one would naturally regard the beds as of the same age; but, if so, the character of the group varies very much in the two localities.

[1] Rec. Geol. Surv. Ind., XIX, 203 (1886).
[2] Mem. Geol. Surv. Ind., XX, 45 (1883).

The eastern termination of the anticlinal hill at Khattan, though cut by faults, presents much the same appearance as those which terminate along the Harnai route, and there is no indication that the whole hill is not composed of limestone; yet, at the head of the tributary valley, which joins the Khattan stream just before it joins the Chákar, this limestone is seen to be underlaid by shales very similar to those of the overlying Ghazij group, and in the borings it was penetrated with a vertical depth of 152 feet, [1] or allowing for a dip of 20°, a thickness of 143 feet, shales with subsidiary beds of limestone predominating below it. In the tributary which joins the Chákar from the south, next above the junction with the Khattan stream, a deeper section is seen; a great thickness of shales is underlaid by the pseudo-conglomerate which was estimated, though not measured, as over 100 feet in thickness; below it comes about 600 feet of shales followed by a band of dark limestone full of oyster shells, and below that more shales and sandy beds.[2] From this it will be seen that, if this band of pseudo-conglomerate marks the top of the Dunghan group, it is either much thinner or much more argillaceous in its character than near Harnai and Spintangi.

Ghazij group.

Overlying the Dunghan limestone, there is a great thickness of grey and olive-green shales, with subsidiary beds of lime and sandstone and, locally, of coal. This I propose to distinguish as the Ghazij group, naming it after the valley which runs down from near the Dunghan mountain to Spintangi. The group consists principally of grey and olive-green shales of various degrees of hardness, which have, for the most part, a somewhat concretionary structure, causing them to weather along spheroidal fracture surfaces as well as the, usually more or less flat, joint and lamination planes; there are numerous concretions, differing from the general matrix only in containing a larger proportion of lime, which not infrequently contain organic remains only seen in section on the fractured surface. Interbedded with the shales are, in places, some bands of brown ferruginous sandstone, usually thin and insignificant compared with the shales; an exception to this statement must, however, be made as towards the upper part of the group, especially towards Harnai and Shahrig.

Present distribution of coal

Near Spintangi only a few thin carbonaceous beds, but no coal, have been found in this group; near Sunari station some thin bands occur near the top of the group, and near Harnai there are several bands of coal, some of them thick enough to be worth working; at the same time sandstone becomes much more abundant in the upper part of the group and several beds full of marine fossils occur. Near Shahrig the development of coal, sandstone and marine fossils is even more conspicuous; in the valley of the Shahrig stream and in the side valleys draining into it coal outcrops may be counted by the hundred, though these do not represent so many separate coal seams. The beds are much contorted, and there are many repetitions; still, after making every allowance, there must be some eight or ten or more seams

[1] This is taken from the "Log of No. 1 boring at Khattan," printed in the Proc. Govt. Ind. P. W. D., June 1886: in a previous volume (XIX, p. 209) of these Records, there is a section, apparently of a different boring, although the total depth is the same, in which 215 feet of limestone are recorded; this would give a reduced thickness of 202 feet.

[2] At a still lower horizon Mr. Townsend has recently discovered a number of fossils including *ammonites*, *ceratites*, and some fragments of those aberrant forms of *ammonitida* which are found in cretaceous beds.

of over four inches thick, besides numerous thinner layers, while both shales and sandstones teem with thin papery laminæ of coaly matter, and leaf remains are extremely abundant. Associated with the coal and sandstones are many fossil shells all of shallow-water type, frequently forming beds of shell marl and not seldom mixed up in the most extraordinary manner with the coal seams.

Due to original limitation of coal formation.

I have no doubt that the local distribution of the coal is due to an original limitation of the conditions under which it could be formed, that the upper portion of the Ghazij group about Harnai and Shahrig is of deltaic origin, and that these beds are elsewhere represented by shales of sub-marine origin, in which coal could not be expected to occur.

Fossil plant remains.

The development of sandstone beds which accompany the coal has already been noticed, and in these innumerable fragments of leaves, and occasionally fossil wood, can be found. The leaves where recognizable are almost universally parallel veined, shewing a great preponderance of monocotyledonous vegetation. The fossil shells occur with both valves still united, imbedded in the mud in which they lived and died; in fact the whole appearance of the rocks indicates deposition in the immediate proximity of land; just such conditions as exist in a modern tropical or sub-tropical delta in which deposition proceeds tranquilly with alternations of sand and mud. As the deposits from time to time reached the surface of the sea a rank vegetation established itself, which is now preserved as coal, while, in the creeks and backwaters, decaying vegetation mixed with mud to form the numerous layers of carbonaceous shale. This delta never extended beyond Spintangi, and it was only late on in the period of time represented by the group that it extended as far as Sunari, where a few thin bands of coal and carbonaceous shale were formed before the land once more sunk beneath the sea and allowed the clear deep water limestones of the next group to be deposited.

Deltaic conditions.

Conglomerate.

Near Harnai a band of strong conglomerate is found, close to the top of this group, and is seen everywhere between it and the hills south of Shahrig, always occurring some distance above the uppermost bed of coal or carbonaceous shale. The pebbles range to four inches in diameter, and sometimes more, being composed principally of red, grey, jaspideous or cherty, rock, but there are also numerous pebbles of grey limestone, in none of which have I seen any trace of a fossil. These limestone pebbles are probably derived from the cretaceous limestones which are known to occur at different spots in Baluchistan.

Thickness.

Owing to the softness of the beds composing this group they have been disturbed in a most capricious manner, and it is difficult to estimate the thickness with accuracy. Near Spintangi it is not far from 3,000 feet, but at Shahrig this thickness must be considerably exceeded. Towards Khattan the thickness appears to be less, not more than 1,500 to 2,000 feet, according to the horizon at which the upper limit is drawn.

Spintangi group

Above the Ghazij group there comes a series of beds which, owing to their lithological difference, I have separated under the name of the Spintangi group. There is, however, a perfect conformity of

stratification between the two groups, and, though there is no difficulty in separating them at and near Spintangi, the same cannot be said of other parts of the country examined. The following is the section of the group as exposed in the cuttings along the line of railway and the military road at Spintangi:—

		feet
1	Cream coloured compact nodular limestone containing an abundance of *Nummulites, Alveolina, &c.* . .	50
2	Compact pale grey limestone . .	24
3	Gap: principally shales . .	10
4	Compact pale grey limestone . .	37
5	Nodular limestones and some shale not well seen .	31
6	Compact pale grey limestone . .	78
7	Gap: apparently principally pale ochreous shales and soft limestone	15
8.	Limestones, somewhat nodular .	1[illegible]
9	Gap: apparently principally shales mostly pale olive green and limestone bands and a bed of gypsum .	26[illegible]
10	Shales marls and limestones: the prevailing colours are pale [illegible] grey to white, but some thin bands of olive shale occur	04
11	Nodular limestone . .	60
	TOTAL	1[illegible]6

The "nodular limestone," referred to in the above section, is a pale usually yellow coloured, limestone compact in the centre of the nodules but soft and earthy looking on the weathered surface. Owing to the resistance offered by the nodules to the action of the weather being greater than that of the intervening matrix the latter has been dissolved out near the surface, and the rock, in consequence, often acquires very much the appearance of a limestone conglomerate. It is evidently the same rock as is described by Mr. Griesbach in the Bolan.

Transition between groups.

Even at Spintangi there is a band of similar limestones detached from its associates and interbedded with the sandstones of the upper part of the Ghazij group, and, near Na[illegible] there are several bands of similar rock, overlaid by a considerable thickness of sandstones and shales among which are some thin carbonaceous bands. At Khattan the difficulty of separating the two groups is even greater. The crest of the scarp opposite Khattan is composed of nummulitic limestones which appear to correspond to Nos. 1 to 6 of the section at Spintangi, below them comes a series of beds of limestone and olive shales, among which are no less than three beds of gypsum, a thin band of bad coal and, below this, four bands of nodular limestone, precisely similar in type to those of the typical Spintangi group, are interbedded in olive shales of the Ghazij type.

Upper beds near Khattan.

Above the principal band of compact limestone at Khattan, which has an unmeasured thickness of several hundreds of feet, olive shales and gypsum come in once more. Of these, the following section has been measured by Sub-Assistant Hira Lal in the neighbourhood of the road to Khattan:—

		feet.
1.	Pale limestone	55
2	Olive shales	100
3	Whitish and carbonaceous shales	12

		feet.
4.	Marly beds and ferruginous nodules[1]	3
5.	Carbonaceous and ferruginous shales	6
6.	Nummuliferous limestone, argillaceous above	30
7.	Greenish shale	50
8.	Brown and green shales	40
9.	White limestone	1
10.	Brown and olive shales	108
11.	Gypsum	8
12.	Olive shales	160
	TOTAL	573

The section is overlaid by Siwalik beds and underlaid by nummuliferous limestones of the Spintangi group.

Overstep of upper-beds.

At its upper limit the Spintangi group is cut off by a slight but distinct unconformity, hardly noticeable as a rule on individual sections, but made very palpable by the distinct overstep of the upper beds by the rocks of the Siwalik system. Thus the whole of beds Nos. 1 and 2 of the section just given are lost in the Koura Pani, only two miles off, and the whole of the section is lost long before we reach Tung. North west of Spintangi, in the hills west of Harnai, the Spintangi group is very much reduced in thickness and, towards Shahrig, only about 60 to 100 feet of limestone appears to be left ; but whether this is altogether due to the removal of the upper part of the group, or in part to the replacement of the lower by sandstones and shales of the upper Ghazij type, could not be determined with certainty.

Peculiar occurrence of gypsum.

One of the most remarkable peculiarities of this group, and one very difficult to explain satisfactorily, is the occurrence of beds of gypsum associated with clear fossiliferous limestones. The accepted explanation of stratified deposits of gypsum requires an inland sea, or shallow lagoon, in which water can be concentrated by evaporation, and, in conformity with this, gypsum is usually found associated with red unfossiliferous clays or sandstones. Here, on the other hand, the beds in immediate contact with the gypsum are green or grey shales, not infrequently fossiliferous, only occasionally shewing a tinge of dull red, and with these shales are interstratified bands of clear, highly fossiliferous limestone, that must have been deposited in an open sea, free from any kind of sediment. It would almost seem as if some beds of limestone had been converted *in situ* into gypsum ; and, though it is difficult to understand why only some of the beds should undergo such a change while the others show no trace of it, the hypothesis receives some support from the fact that, near Sunari station, several of the beds of limestone and marl contain numerous irregular lumps of white saccharoid gypsum, which at times form almost half the whole substance of the rock. These inclusions are doubtless of chemical origin, subsequent to the deposition of the beds, and a continuation of the same process would in time have converted the whole into beds of pure gypsum.

Siwalik system.

The area occupied by Siwalik beds has been only very cursorily examined, and as regards their general characters there is nothing material to add to the already published descriptions. The uncon-

[1] Pyritous? R. D. O.

formity at its base, indicated by the overstep of the upper beds of the Spintangi group, is also shewn as an actual, though not very conspicuous, unconformity of contact. The most conspicuous instance is in the cliff section on the left bank of the Chákar, close to the road to Khattan; here olive shales are overlaid by a bed of pale limestone whose upper surface has been distinctly eroded before the deposition of the overlying Siwalik beds; another more easily accessible instance is in the railway cutting close to the tunnel at Spintangi, where, a foot or so above the base of the Siwalik sandstones, a band of conglomerate is composed of pebbles of compact pale-coloured nummuliferous limestone, precisely similar to the rock through which the tunnel is driven.

Unconformity of contact.

Besides these proofs of unconformity, there is a distinct overlap of the lower beds of the Siwalik system. In the hills west of Harnai the lowest beds of the Siwaliks are principally clear grey or greenish grey sandstones, which, when seen from a distance, contrast very conspicuously with the overlying dirty pepper-and-salt sandstones and red earthy clays. This same lower group of sandstones is seen on the Spintangi section, and can be traced eastwards continuously to Tung, preserving all this way a considerable thickness varying, at an estimate, from 200 to 500 feet. Beyond Tung it thins out; near Mírdíd it is hardly, if at all, represented, and on the sections near Koura Kumb, about 10 miles from Khattan, there is no trace of these lower sandstones which have been completely overlapped by the overlying dirty sandstones and red earthy clays.

And overlap.

Recent and sub-recent stream deposits are largely developed in the valleys; they consist of fine and coarse gravel and coarse sandy stuff, precisely similar to the debris brought down by the streams at the present time. The gravels are everywhere quite undisturbed, and have only a gentle dip due to the original slope of deposition; rarely a local dip of 25° to 30° can be found, one instance being by the side of the railway between the tunnel and station at Spintangi, another is about three miles east by north of Seni village. The explanation of these local dips is to be found in the sudden floods which scour out deep holes, afterwards filled up again as the stream subsides. It is a peculiarity of floods, in a country devoid of vegetation, that they rise and fall with great rapidity and the cessation of power to excavate or keep excavated a deep pool would be abrupt; after that the falling stream would sweep its debris into a pool of still water, forming a delta with a steeply sloping termination over which the debris would roll down. In the instance at Spintangi there is, in close proximity to the inclined beds, a rib of limestone standing up in the gravels, which would quite account for the excavation of a pool in its proximity, and it is to be noticed that, in the only two instances where a dip, steeper than the general gentle slope of deposition, has been found, it is extremely local and coincides with the natural angle of repose of the gravels in water.

Recent and sub-recent gravels.

In this connection must be mentioned the numerous and often extensive deposits of tufa or travertine scattered about the valleys and capping the terraces of gravel. They have evidently been formed by springs, the most conspicuous of whose few and feeble modern representatives is that directly opposite the station of Spintangi.

Tufa deposits.

II.—STRUCTURE.

Anticlinal flexures.

Along its northern and eastern limits, the country examined is marked by a series of anticlinal flexures advanced one beyond the other in echelon to the west. The most easterly of these is that which terminates at Khattan. Almost due north of it another appears to terminate in the hill of Gidari, but this has not been examined. North-west of this another anticlinal terminates at the Miri hill; a fourth forms the Dunghan hill; a fifth the Galusha hill, which ends opposite the Spintangi station; a sixth is the ridge of the Pír Kóh; a seventh terminates near the village of Seni; and the last and largest forms the high ridge north of Harnai dying out to the north of Shahrig after having sent off a small offshoot just west of Mfráb Tangi.

Offshoots of an area of elevation.

These anticlinal axes appear to be one and all offshoots from the great region of elevation which lies east and north of the Harnai route to Quetta, and as their cores are composed of the hard Dunghan limestone, they form a very conspicuous orographical as well as structural feature of the country.

Replaced by monoclinal flexure.

Between Spintangi and Harnai this system of east and west folding gives way on the line of its strike to a simple monoclinal fold which brings in the Spintangi group and Siwalik beds. Above Harnai, and in the Ghazij valley, there are first of all synclinal folds in which outliers of Spintangi and Siwalik beds occur. The monoclinal fold which forms the main boundary of the Siwalik system preserves on the whole a very steady direction, varying from about west-north-west and east-south-east to north-west and south-east, with but few sudden changes of strike or interruptions of continuity.

Interruptions of continuity.

The first of these interruptions is south of Harnai, where it is cut by an anticlinal fold which turns the boundary sharply to the south, a little further east, it turns as sharply to the north, and a couple of miles beyond the first bend resumes its original course. A second is about six miles south-east of Spintangi, and corresponds to the termination of the Dunghan anticlinal and the coming in of a synclinal fold, in the Ghazij valley, directly on its line of strike; here the dip of the beds is irregular, and the crest of the ridge formed by the Spintangi group is shifted about half a mile to the south-west. The third is a combination of anticlinal and synclinal folding, which causes the outcrop of the Spintangi group to take a sharply bent sigmoidal course near Khattan.

"Skew flexures" producing appearance of anticlinal folds.

The dip of this monoclinal flexure is generally normal but in places reversed, and the change from normal to inverted dip is generally sudden and abrupt by what might be termed a "skew flexure," were it necessary to invent a name. The sharp twisting of the beds where the dip changes suddenly from normal to reversed has fissured them and set up a region of comparative inability to resist denudation, with the result that a stream valley has established itself on every one of these twists, and a further result that the outcrop of the harder beds can be traced continuously arching over from a north-easterly to a south-westerly dip. Looked at from a

distance this bending over of the outcrop, which is especially conspicuous about six miles south-east of Spintangi, produces a most deceptive imitation of an anticlinal fold, but when the section is examined on the ground, it is seen that the opposing dips are not on the same line transverse to the strike and are separated by a zone of irregular dips often directly along the general strike of the beds.

"Monoclinal fan structure" near Spintangi.

At Spintangi and Tung the compact limestone beds, forming the core of the ridge, have a vertical dip, while the softer beds of the Spintangi group to the north and of the Siwaliks to the south, dip inwards towards the centre of the hill. This peculiar structure, combined with the similarity in colour between the upper shales of the Ghazij group and the lower sandstones of the Siwalik series, led me, when passing Spintangi in the train, to regard the ridge as either a fan-shaped anticlinal or a sharply folded synclinal flexure. A more careful examination of this ridge and a comparison of it with other sections has shewn that the section is continuous from bottom to top, and that the soft beds have been squeezed out below by pressure against the hard limestone core, producing what may be called a monoclinal fan structure. It may be that the comparative absence of shaly beds from the Spintangi group at Spintangi may be due to their having been squeezed out during the great compression of the beds required to produce this structure.

Absence of great faults.

A noticeable feature in the structure of the country examined is the absence of great faults. There are numerous small faults, too small to be marked on the map, though even these are less abundant than one might have expected, but there are no great master faults, such as are usually abundant in highly disturbed districts. One such does seem to run past the foot of the Kaliphat hill, and thence east-south-east past the camping ground known as Berkeley's bottom, on the road from Harnai to Loralai, but it is outside the area examined, and its existence has not been established. In the Siwalik area between Spintangi and Nari there may be some faults of large throw, but the ground has not been examined in sufficient d... l to determine this point With these possible exceptions, the beds have ... ely been thrown into a series of folds, often very sharp, but, in general, unaccompanied by any faulting except on a small scale.

III.—OROGRAPHY AND HYDROGRAPHY.

Connection between orography and structure, indirect.

There is a very close connection between the orography and the structure of the country under description, though the connection is as usual not direct, but indirect; that is to say, the hills are not always regions of special structural elevation, nor the valleys of depression, and even where they are, the surface features have been profoundly modified by sub-aerial denudation; but the disturbance of the beds has brought rocks of very various degrees of hardness within the reach of . in and rivers, and these, acting at different rates according to the rock attacked, have carved out the present contour of the ground.

Anticlinal hills.

The various anticlinal axes in the Dunghan limestone all form conspicuous hills, and are the only ridges which are structurally axes of elevation. Even in these, the present contour of the ground is very different to what it would be were all the beds replaced, for the whole of the Spin-

tangi and Ghazij groups, probably also most of the Siwalik system, have been washed away, and the hills are now grey hog-backs, nearly destitute of soil or vegetation, the surfaces of which are often formed, over large areas, by a single bed of limestone.

Scarp of Spintangi and Siwalik beds.

The outcrop of the Ghazij group is everywhere marked by low ground, while the Spintangi group, owing to its superior hardness, always stands up as high ground. Above Nasik, where the limestones of the Spintangi group are much reduced in thickness, the massive sandstones of the lower part of the Siwalik system help them to form the synclinal hills south of the line of railway between Harnai and Shahrig, as well as the conspicuous scarped ridge, separated from these lower hills by an anticlinal axis, along which beds of the Ghazij group crop out, and marked everywhere by a comparative depression of the surface.

Synclinal hills.

Hydrography independent of structure.

But, though there is this close connection between the structure and orography, the hydrography or drainage of the country shews a complete independence of either. To the east the area examined is not sufficiently extensive to give many instances of this; yet both the Chákar and the Bheji rivers break through the high ridge of Spintangi limestones. In the long valley-like depression, occupied by Ghazij shales and sub-recent river gravels, which extends from Spintangi to beyond Shahrig, there are no less than four streams that flow directly across the strike of and through the ridge formed by the limestones of the Spintangi group and the sandstones of the Siwalik system; a fifth cuts through the continuation of the same ridge about four miles west of Sharigh. Moreover, of these five streams, no less than four enter the low ground through gorges or "Tangis" in the anticlinal ridges of the Dunghan limestone to the north. The stream west of Shahrig is the same that carries the drainage of over a thousand square miles through the famous Chappar rift; the Nasik stream flows out through a gorge near Wangi, six miles north-east of Shahrig: the Harnai stream issues from the Wan Tangi; and the drainage of the Mfiah Tangi, through which the road to Loralai is carried, and of the Tarai Tangi, flows out through the Spintangi near the station of that name. There are thus not only five gorges by which the drainage cuts through the scarp and across the strike of the Spintangi limestone, but there are four, or, if we include the Chappar, five, rifts through which the drainage finds its way across an anticlinal ridge, *i.e.*, an area of special elevation.

Popular explanation of gaping fissures.

The popular explanation of this feature is, that the rifts and gorges are gaping fissures through which the streams have found an exit. This idea is fortunately fast dying out; it has often been refuted, and is insufficient in itself, as it fails to account for the excavation of the valleys leading up to the gorges; moreover, it can be distinctly disproved in this neighbourhood, for not infrequently the solid rock can be traced continuously across the bed of the stream without the slightest breach of continuity.[1]

Insufficient and impossible.

[1] As an exception to this general statement, there is a conspicuous fault in the Spintangi, but as it makes an angle of 60° with the general direction of the gorge, passing out of one side of it, and, after crossing the stream, into the other, this fault cannot be said to help the hypothesis.

Another explanation once, and still to a certain extent in vogue, is that the streams formerly flowed at a higher level than the tops of the present hills, over a plane of marine denudation which, sloping across the strike of the rocks, gave the streams their initial direction, and that the contour now existing is due merely to subaerial denudation acting on rocks of various degrees of hardness. The assumption of a plane of marine denudation would be entirely gratuitous; no trace of it remains, and it is, besides, only necessary, if we also assume that the disturbance of beds was altogether prior in date to the establishment of the present drainage system.

By plane of marine denudation, unsupported and unnecessary.

The third hypothesis, suggested by Dr. Blanford, is that the elevation of the hills, or, to speak more correctly, the disturbance of the strata, which, by exposing beds of varying hardness to the action of subaerial denudation, led to the unequal erosion of the surface and hence to the formation of the present contour, is of more recent date than the drainage system; but that the disturbance has been sufficiently slow for the streams to maintain their original courses by erosion.

Third hypothesis disturbance of beds newer than drainage system

Besides being in itself the best hypothesis proposed, there is a certain amount of evidence in its favour; for it can be shewn that since the present drainage system was established, the scarped ridge south and west of the railway from Spintangi to Shahrig has been subjected to elevation, and there is no reason why this ridge should have been elevated while the rest of the country remained stationary.

Direct evidence recent disturbance.

Throughout the depression formed by the Ghazij group there are extensive deposits of river gravels rising to a height of, at times, some hundreds of feet above the present stream beds. These in themselves prove nothing, for they might well be mere terrace deposits formed by the streams as they gradually cut their valleys downward, but here and there the gravels can be seen extending right down to the level of the stream bed. There is one very conspicuous instance about a mile east of Harnai, where some cliffs over 100 feet in height are composed of river gravels throughout, and, opposite the Spintangi station, there is a terrace of gravel rising 80 feet above the present stream bed.

River gravels extending down to stream bed.

These gravel deposits, extending right down to the present level of the stream, shew that the valley had been cut down to its present depth, that the current was then checked by a comparative elevation of the bed in a lower portion of its course, and that the stream began to fill up its valley with gravel till, the conditions being once more changed, it cut down again through the gravels it had deposited.

Prove recent elevation.

If we turn to the gorges through which the streams find their exit to the south-west, we find the same story told. Without exception the stream beds are narrowed in the gorge and from them the sides rise sheer with a nearly vertical face to a height of some 50 to 80 feet; at the top of this vertical face of rock the valley suddenly opens out, and the slopes sink to 40° or less. There can be no doubt that this upper open portion of the gorge marks a period during which the stream bed had attained a condition of comparative equilibrium, and the deepening of its

Gorges shew a period of stability followed by elevation.

channel went on so slowly that frost, heat and rain were able to disintegrate the rock and slope away the sides of the valley. Then the bed of the stream was elevated, and this would have a two-fold effect: in the first place, the current of the stream would be checked above the gorge, it would no longer be able to carry its burden, and river gravels would be deposited in the valley above the gorge; in the second place, in the gorge itself, the stream would begin to cut down its bed at a more rapid rate than before, more rapidly too than the action of the weather would be able to slope away the sides, and so the lower, vertical sided portion of the gorge was formed.

Summing up.

We have then, whether we examine the deposits of the streams or the gorges through which they escape, the same tale of a recent elevation of the scarp to the south of the route between Spintangi and Shahrig, and, as I have said before, it is not conceivable that the disturbance which has taken place since the drainage system was established should have been confined to this ridge alone.

Minor changes of drainage.

Although the drainage system has maintained its general character during the disturbance of the strata, yet there must have been many minor changes. Thus the streams which drain the southern slopes of the Kaliphat mountain, after collecting together, divide, part of their water joins the stream which flows from Mangi through the Chappar rift, and part escapes through the gorge south-east of Shahrig: no doubt during the history of this stream it has, at times, discharged the whole of its waters through one or other of these gorges. So too, the stream that now issues at Wangi and flows down to Nasik has doubtless at one time flowed over the Pungah uplands and out through the gorge of the Shahrig stream. The shape of the old fan of the Wan Tangi stream shews that it too at one time flowed out of the Nasik gorge and not, as now, past Harnai, while it is not impossible that the waters of the Mfi.ah or part of them may once have flowed through the same gorge, and it is certain that they must once have flowed through the gorge of the Harnai river instead of, as now, running down to the Spintangi. All these changes, except possibly in the case of the Shahrig stream, are of extremely ancient date, measured by human chronology, for the present streams have cut for a considerable depth into their old fans, which are besides scored with innumerable ravines cut back into them to depths ranging to a hundred feet or more.

IV.—ECONOMIC RESOURCES.

The only mineral products of economic value consist of coal and petroleum, the latter of which is at present being worked at Khattan.[1]

Petroleum.

The existence of petroleum at Khattan has long been known to the natives of the country, Khattan being, in fact, primarily the name of the substance and only secondarily the name of the place at which it occurs, but it is only within the last few years that any attempt to exploit it has been made. The oil which flows at the surface, equally with that obtained from

[1] The passages that follow are not intended as an exhaustive account of the occurrence of petroleum at Khattan: this has been fully reported on by Mr. Townsend, but it could not be passed without some notice here

the deepest of the borings as yet put down, is a black, tarry, viscid substance which becomes semi-solid at temperatures below 60° Fahr.

It flows in small quantities at the surface, issuing from fissures in the rock along with an abundance of hot sulphurous matter; besides the present flow, there are abundant traces of former flows in the river gravels at Khattan, and at intervals up the valley for at least ten miles; it also occurs abundantly both comparatively fresh and dried up to the consistence of hard pitch, along fissures in the limestone of the Dunghan group and in the Ghazij shales.

Although the oil occurs in both these groups, it is indigenous in neither; no trace of it can be found in the substance of the rock, but only along the fissures through which it flows from beneath. I think the same may be said of the shales, underlying the limestone, which yield the oil at present being worked. A careful examination of the fragments brought up from the borehole showed no trace of any impregnation of the substance of the rock; and the original source of the petroleum must be looked for at a still greater depth.

At the time of my visit four wells were being pumped, of which one was yielding 10 barrels of oil a day; in the other three a good deal of water was being pumped, mixed with oil to the extent of 10, 6 and 4 barrels a day respectively, or an average of 7½ barrels per diem. At this rate it would require at least 25 wells to supply the 50,000 barrels per annum, which is the amount that would be required by the railway alone. It is possible that future borings may yield a higher average than this, as the rocks at the site of the present borings are very much shattered and intersected by fissures along which the oil finds an outlet at the surface, while to the south of Khattan there are some three or four square miles over which the shales lie horizontal or nearly so. The cover here is much better than at Khattan itself, and it may be that oil would be found under greater pressure than in the present borings. The experiment will probably be tried during the present working season.

Till recently no occurrence of petroleum was known between Khattan and Kirta on the Bolan, but during the examination of the country under description numerous traces of it were found in the Dunghan limestone of the Harnai valley. Between Spintangi and Harnai the railway passes to the west of these anticlinal ridges, all of which end up with a rounded surface of limestone, dipping away in every direction, from which the overlying Ghazij shales have been completely washed away.

In every one of these traces of petroleum are to be found in the limestone, most abundant on the crest of the anticlinal where this dips under the shales. It is not too much to say that anywhere along the termination of these anticlinal ridges bitumen, the dried-up residue of the petroleum, can be found by a very cursory search indeed; and even along the flanks of the anticlinals there are here and there localities where traces of it more or less abundant can be found.

The most common mode of occurrence is as inclusion in calcite veins and, where the crests of the anticlinals run underground and occasionally for some hundreds of feet up them, every vein of calcite, whose structure shows that it has been deposited by water flowing up from below, contains more or less abundant inclusions of bitumen. These may be so minute and scattered as to be only detected after a careful examination with a powerful lens, or they may be so numerous as to produce a

brown, even almost black, colouration of the calcite; at other times they are large enough to be easily distinguished by the naked eye, and may range up to quarter of an inch in diameter and occasionally more, while the general mass of the calcite is of a white colour. Besides this mode of occurrence the petroleum is found coating joint planes, and permeating fissures, in the rock, and these fissures are often not the principal joint planes but close conchoidal fractures which seem to have been formed during the disturbance of the beds. As a rule, the volatile constituents have completely evaporated and nothing is left but a brittle mineral pitch which, at any rate during the cold weather, does not soften even when exposed to the sun in the middle of the day; at one spot, however, on the south side of the Pír Kóh, and about $1\frac{1}{2}$ miles from its termination, the stuff found coating the fissures is sometimes quite soft when the rock is first broken.

At Khattan traces of petroleum are found abundantly in the shales overlying the limestone, but in the Harnai valley they are few, faint and far between. The difference I attribute firstly and principally to the much less faulted condition of the beds in the latter, and to a less degree to the fact that, at Khattan, rapid erosion of the stream bed is going on and numerous exposures of unweathered shale can be found, while in the Harnai valley the streams are in a state of comparative equilibrium, there are vast expanses of recent gravels, and such exposures of shale as are seen, are nearly always weathered and crumbling at the surface.

Besides the absence of conspicuous "shows" in the Ghazij shales, the Harnai district differs from Khattan in the want of any actual flows of oil at the surface. This may be due to one of three causes, either (1) there was never a sufficient amount of oil in this region to allow of its flowing at the surface, or (2) the whole of it has already escaped, or (3) the conditions are not such as to allow of its escaping at the surface. As it is of great economic importance to determine which of these three is the true one, I shall examine them each in turn.

The first is in its nature as incapable of proof as of disproof; against it may be set the invariable occurrence of traces of petroleum wherever the circumstances are such as would lead one to expect them, and their frequent occurrence where there is no special reason to be seen. It is in itself improbable, and while no reason can be shown why petroleum should not be as abundant here as at Khattan, there are, as will be shown, very good reasons why it should not flow at the surface.

The second hypothesis may, I think, also be rejected; if surface flows had ever been as abundant here as at Khattan, one would expect to find traces of them in the river gravels, similar to those which are both abundant and conspicuous at Khattan; but none such have been found.

There remains the third hypothesis which I consider to be the true one. At Khattan the termination of the anticlinal in the limestone is cut by numerous faults, and it is along these faults that the hot water and petroleum rises to the surface; in the Harnai valley faults are few and small, and the rocks are so well exposed that it is possible to say that they are practically absent from the ends of the above ground portion of the Galusha, Pír Kóh, and Seni anticlinals. A far more important point, however, is the comparatively low temperature of the springs which issue at the surface; at Khattan they range from 105° to 115°F., while in the Harnai valley, they have mostly a temperature of about 90°, the highest measured being

94°F. Now, the maltha of Khattan, and the similar oils that have been obtained at Shoran and Kirta, cannot be said to attain any degree of fluidity, a real freedom of motion, till their temperature rises above 100°Fah., so that in this alone we find sufficient reason why no petroleum issues at the surface.

Another argument leading to the same conclusion may be drawn from the manner of occurrence of the oil-shows. The most abundant shows on the termination of the Galusha hill are to be found about a mile east of the station of Spintangi, where a small sulphur spring issues, the water of which is led off in an irrigation channel; in the ravine above this spring oil-shows are very conspicuous both as large inclusions of mineral pitch in calcite veins and as sheets of the same substance, sometimes a quarter of an inch thick, lining all the joint planes and fissures in the rock. This is not only the place where oil-shows are most abundant, but it has the lowest absolute level of any exposure of the limestone of this hill. In the second small valley to the north-west of this, the limestone is again exposed, but at a higher absolute level, oil shows are not nearly so conspicuous as at the first place, but they occur both as inclusions in calcite and as intrusions along the joint planes; the difference in level between these two localities was not measured, but it is about 50 or 60 feet; above the first locality bitumen is found at a still higher level up to 200 feet, but at these higher levels the only traces of oil found were small inclusions in calcite veins. Granting that the difference may be in part due to greater local facilities for the upward flow of oil at the first locality, it seems as if the larger globules of oil were entangled and detained at the lower level, while only the smaller globules were carried upwards by the more mobile water to the higher levels.

At Pir there are not the same facilities for observing this relation, but on the Seni anticlinal we again find this superior abundance of oil-shows at lower levels, thus pointing to a still greater abundance further down.

It must be remembered in this connection that the specific gravity of the Khattan oil is the same as that of water at a temperature which has not been precisely determined, but is about 60°; owing to its greater co-efficient of expansion the specific gravity is slightly greater than that of water below this temperature and slightly less at higher temperatures. In consequence of this the oil would collect under the crest of an anticlinal fold in a permeable stratum overlaid by one that was impermeable; but if there was a fissure leading to the surface to which both water and oil had access, the slight difference of specific gravity would be largely counteracted by the greater viscosity of the latter, and the discharge at the surface would be principally water, bearing globules of oil in suspension: moreover, the viscosity of the oil increases so rapidly with a fall of temperature as to make it probable that, at temperatures below 100°, there would be no escape of oil at all.

These considerations lead me to the conclusion that there is probably an abundant supply of oil underground in this district, and that borings judiciously placed would yield it in paying quantities; at any rate the experiment is worth trying.

Coal.

The general distribution of the coal has already been noticed under the section devoted to stratigraphy, but requires fuller consideration from an economic point of view.

The most southerly point on the Harnai route at which coal has been found is near the station of Sunari. A few thin bands occur high up in the Ghazij group

and crop out along the face of the hill side. They have been opened out in one or two places, and a certain amount of coal appears to have been removed, but the thickest seam is only a foot in thickness and quite worthless economically.

The same coal occurs on the face of the hill west of Harnai station and in the valley between this and the Torghar ridge. In this valley better coal occurs at a lower horizon, and at a spot about four miles from Harnai station by the path, and two miles south by west in a direct line, the following sections were measured by Sub-Assistant Hira Lal:—

	Limestone.		
	Coal (good)		6"
	Olive shales	5'	0"
	Carbonaceous shale		2"
	Shale, with a band of limestone	10'	5"
	Carbonaceous shale		6"
	Green shale	2'	0"
	Inferior coal with fossil shells	1'	0"
	Coal		5"
	Green shale	4'	0"
No. 1	*Coal*		8"
	Carbonaceous shale		1"
	Coal		5"
	Shale		1"
	Coal		4"
	Greenish and carbonaceous shales	16'	0"
	Fossiliferous limestone	3'	0"
	Carbonaceous shale		4"
	Green shale	1'	8"
	Carbonaceous shale		8"
No. 2	*Coal*		9"
	Inferior coal and carbonaceous shale		5"
	Coal		6"
	Greenish shale with bands of carboniferous shale and coaly matter	28'	5"
	Coal		4"

Below shales, &c., with bands of carbonaceous shale and coal.

There are here two very fair bands of coal of sufficiently good quality and thickness to supply fuel for lime or brick burning, though not thick enough to pay for systematic mining in spite of the very favourable assays.[1]

In the nullas draining southwards between Nasak and the Pungah ghât, several outcrops of thin seams of coal are reported by sub-assistant Kishen Singh. One outcrop, about a mile west of the village of Rajani, is being worked by a contractor to supply fuel for lime burning. The exposure is in the bed of the stream, and the following section was measured by me:—

Green and grey shale.		
Coal		11½"
Grey shale	12'	6"
Carbonaceous shale		1"
Grey shales containing calcareous concretions	7'	0"
Coal	0'	4"
Grey and green shales	15'	3"
Coal	1'	1"
Shale.		

[1] These are given at the end of this report. No. 1 is especially good for a surface sample: it can hardly represent the average composition.

The beds dip 35° to S. 35° W., and the extraction of coal will soon be stopped by water, still about 450 to 500 tons of coal can be extracted from surface workings in this place. It is a pity that these seams are not thicker, for the coal is a hard black coal free from pyrites and makes an excellent coke. It is the best looking coal I have seen in this district, bearing in mind that it was obtained from surface workings.

At Shahrig coal has been worked for several years, and has been described before now. The section measured and recorded by Dr. Blanford[1] gives a good idea of the general character of the beds containing coal; it is possible that this section may contain some repetition of the beds by folding, though I have not been able to detect such with certainty either in the section or in the field, but nearly all the other numerous exposures of coal in the Shahrig neighbourhood appear to be repetitions of the same beds or others on the same horizon. Owing to the thinness of the seams and the great disturbance the beds have undergone, it would not be worth while to attempt regular mining operations, but coal is being obtained from surface workings at the rate of 70 tons a month, and there is sufficient area of coal bearing beds to supply this quantity for many years to come.

Gypsum.

Gypsum occurs in considerable quantities near Khattan There are four distinct beds of it which range up to 8 feet thick, consisting of pure white or pinkish alabaster. This may be worked at some future period, but is of no present value. A band of gypsum occurs in the Spintangi group at Tung, it can be traced to near Spintangi, and occurs with a thickness of about 4 feet above and west of the station; in the road cuttings through the gorge it is not seen, being hidden there by river gravels. Besides these beds of gypsum, it occurs in the form of selenite, often in great abundance, and large crystals, in the shales accompanying the coal.

Limestone.

Limestone is extremely abundant throughout the area occupied by nummulitic rocks; and even in the Siwalik area the pebbles in the stream beds are almost all composed of limestone. It is of great purity as a rule; in fact, its only fault seems to be that it produces too fat a lime.

Building stone.

Building stone is abundant. The sandstones of the Ghazij group are quarried near Shahrig, but the best stone is that obtained from the lower beds of the Siwalik series, where they have not been too much disturbed. Among the low hills near Nasik quarries might be established, whence an excellent free-stone could be obtained in blocks of large size; the quality is, however, not good enough to establish an export trade, and for local purposes the nearest stone available is used.

[1] Mem. G. S. I., XX, p. 87

Assays of Coal.

	Deep workings of the Khost Colliery. Upper part of Ghazij group. Received from Mr. Baker.	Sharigh Nullah, top of Ghazij group, No. 67 of Blanford's section, Mem XX, 193, now being worked for fuel. R. D. O.	Two miles S. by W. of Harnai Railway station, Ghazij group, near top Sample No. 1. Hira Lal	Two miles S. by W. of Harnai Railway station, Ghazij group, near top. Sample No. 2. Hira Lal.
Moisture	2·20	3·56	8·12	8·60
Volatile matter, exclusive of moisture	40·56	42·60	37·64	34·84
Fixed carbon	47·48	40·12	51·04	49·56
Ash	9·76	13·72	3·20	7·00
	100·00	100·00	100·00	100·00
	Cakes strongly and forms a light tumid coke	Cakes strongly	Sinters slightly.	Sinters slightly.
	Ash—gray	Ash—gray	Ash—dark brown.	Ash—dark red.

Report of a Journey through India in the winter of 1888-89, by DR JOHANNES WALTHER, *translated from the German, by* R. BRUCE FOOTE, F.G S., *Superintendent, Geological Survey of India.*

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In November 1888 I undertook a journey to India and Ceylon in order to make comparative studies of the physical qualities of the continental and marine sediments which are formed and deposited under the influences of the tropical climate. For such researches India appeared to me specially adapted as, thanks to the English Government, it is more easily accessible in all parts between latitude 6° and 30° N. than any other country within the tropical zone. It is the home of the Laterite and of the Regur; its coasts are fringed by recent and sub-fossil coral reefs, and in the south are even marls, limestones, and coral reefs of mesozoic age, which having been formed and metamorphosed within the tropics would yield admirable material for comparison.

Mr. Carl Rumpff, Member of the House of Deputies, took an interest in my problems and accorded me notable assistance; but unfortunately this noble-minded man, so inspired with love for natural science, was cut off by a sudden death shortly after my return. Both in North India and Ceylon I had the good fortune to have in Professor Dr. F. Exner, of Vienna, a fellow traveller who took a lively interest in my studies and to whom I am indebted for valuable assistance.

After spending some time in Bombay to study the admirable sections of the

Laterite in that neighbourhood, I travelled on to Jeypore in Rajputana, and thence through Agra and Benares to Calcutta, and from there to Darjeeling; thence to the Ganges-delta and then back to Bombay. Through the Deccan I proceeded to Madras and Trichinopoly, and thence, travelling in a bullock cart, I visited the cretaceous region around Utatur, Perambalur, Maravattur, Arrialur and Cullygoody. From Madura I drove to Palk's Straits, spent a fortnight in studying the island of Ramesvaram and its surroundings, and thence reached Colombo in a sailing boat. An excursion to the "gem pits" of Ratnapura, and on the Kaluganga to Kaltura, and thence on to Point de Galle made me acquainted with the low lands of Ceylon and its bright coloured coral reefs; another excursion to Kandy, Nuwera Ellia and Pedrotallagalla was dedicated to the study of the local Laterites. Finally on my return journey, I employed a three weeks halt in Egypt in continuing the work I had begun there two years previously.

I owe very hearty thanks, for the very kind assistance they afforded me, to the Officials of the German Consulates, especially Mr. Consul-General Gerlich in Calcutta, Mr. Secretary Junckersdorf in Bombay, Mr. Consul Gerdes in Madras, Mr. Consul Fudenberg in Colombo; also to Dr. King, Director of the Geological Survey of India, Dr. Thurston, Director (of the Museum), Madras, Mr. Collector Fawcett at Trichinopoly, and Mr. Collector Turner at Madura, without whose kind help it would have been impossible to have made so large a number of observations in a relatively short time. As the thorough working out of my collections of the Laterites, Delta and Coast sediments, cretaceous corals from Maravattur, and tertiary corals from Ramesvaram, may occupy a number of years, I propose to limit myself in this short report to points concerning the occurrence and mode of formation of the Indian sediments which I was able to establish when there, and reserve a fuller treatment of the subject for a later occasion.

CONTINENTAL SEDIMENTS.

1. *Laterite.*—The name Laterite is given in the tropics to the products of weathering of different rocks, which, though of very variable physical qualities, are characterized by a red colour. As in our latitudes the weathering of most rocks gives rise to a material coloured yellow by oxydulous iron ("Eisenoxydul") so under the influence of the tropical climate a red earth, rich in iron oxide is formed.

Geographical latitude or hypsometric elevation have no connection with the formation of Laterite, for it is found equally at Point de Galle in Lat. 6° North, and in Sikkim in Lat. 27° N., and at the level of the sea at Colombo as well as at an elevation of 8,000 feet on the summit of Pedrotallagalla. The tropical rainy season, with its constant thunderstorms and the richness in iron salts of the weathering rock masses, appear of much more importance genetically considered. The darker, in other words, the richer in iron a rock is, the more intensive is the redness of the product of weathering. The Deccan basalt, dark varieties of gneiss, garnet gneiss, and other rocks rich in iron weather into a brick-red Laterite, while pale gneisses rich in felspar form a pale-red to whitish-yellow product. The mica schists of the northern slopes from Darjiling down to the valley of the Ranjit, weather to a greyish-yellow powder, while 2,000 feet above, in the Churchhill Park, a formation consisting of dark and light-coloured gneiss beds is decomposed into a Laterite consisting of alternately red, greenish-yellow and brown-coloured beds. (I imagine.

as already hinted above, that the thunderstorms of the tropical rainy season are of importance in the formation of Laterite, because nitric acid is formed in the air by the electric discharges and washed down by the rain. These traces of nitric acid, small though they are, but possibly in combination with the ozone also formed by the thunderstorms, act as oxidizing agents and produce iron salts richer in oxygen than can come to pass in temperate climates with fewer thunderstorms.).

The conversion of solid rocks into Laterite takes place just as in our own latitudes, though with increased intensity, so that Laterites are formed on the surface and along all points and cracks, and so that at a more advanced stage still blocks of the original rock occur in the centre of the laterite mass. While in the case of the Basalt Laterites, the boundary between the Basalt and Laterite is macroscopically a very sharp one, crystalline rock show gradual transitions from a loosened product of weathering to a reddish stained one, and finally to a distinctly red coloured one.

But the Laterites themselves when once formed undergo an ever continuous physical and chemical conversion, so that in this way that great number of varied laterites comes to pass which makes it so difficult in many cases to pass a decisive judgment as to the individual phases of formation.

While it is very easy to understand the formation of Laterite in its original *situs*, as countless sections demonstrate the process, it is very difficult to judge of the mode of origin of a laterite in a secondary *situs*. The transporting and preparatory powers, wind, rain and surf create very varied formations. Laterite, once it is formed, is still further changed by chemical processes; it becomes cellular by the solution of some of its constituents, the iron salts unite into pisolitic concretions. and by the action of standing water, or of a thick covering of humus, laterite is locally reconverted into a yellow loam. Constituent parts are carried away by the monsoons and give to other sediments which have no connection with the Laterites, a misleading Laterite colour (facies), and thereby give rise to sources of error in judging of the gneiss of such rocks.

I have not been able to observe that Laterite has originated in India from limestone, marl, or sandstones; and even the tuff-beds alternating with the basalts of the Deccan do not give a red coloured product of weathering.

2. *The Deposits of the Ganges.*—The great plain of Bengal, the domain of the Ganges and Jumna, is covered by a mighty bed of river sediments brought down by flood waters from the Himalayas. The river beds have in some cases cut deeply into these deposits and have exposed fine sections. The innumerable tanks also, which have been made everywhere, afford good exposures, which show that these sediments consist of thin layers resting horizontally on each other, corresponding thus to the several successive inundations. Nowhere did I observe a departure from this type of thin bedding, and it was only on the bank of the most northerly branch of the Ganges, at Damukdea, where a wide "dust-plain" stretches out and is but little cultivated, that the diagonal bedding showed itself in several sections, but here, as everywhere else, it has come to pass not under the water but by the action of wind. In the region of the Sunderbans, in the environs of Diamond Harbour, where I gave a whole day (in a boat) to the study of the sections in the banks of the Ganges branches, I saw, without exception, nothing but thin-bedded sediments. What especially struck me there, was, that I could nowhere find traces of imbedded wood and other plant remains. With reference to calculations as to the amount of sedi-

ment carried into the sea within any given time, one observation I made is by no means devoid of import, namely: when the flood tide commences the whole contents of the Hugli are driven up stream with such force that it is impossible to row down stream even with a pair of rowers.

If the sediments of the delta are compared with those, which occurring further up country form, for example, the river banks at Benares, it is a striking fact that here the sediment is divided by strings of calcareous concretions into hard and soft beds.

In treating of the Laterites I have already referred to the formation of concretions as a phenomenon brought about by subsequent metamorphoses of the original laterite rock, and, as I shall have to describe later on, concretions of considerable dimensions appear characteristically in the cretaceous sedimentary rocks of South India. The occurrence of such concretions in river deposits, in marine sediments, and in continental laterite formations, appears, therefore, to be a common and distinctive structure in various tropical sedimentary formations. I trace back the origination of these to the fact that during the tropical rainy season all sediments (formations) are percolated by water, but become desiccated during the dry season.

By this alternation of permeation by water, mineral solutions are formed in the sediments periodically and are periodically precipitated. In this way certain calcareous beds will become increasingly rich in lime at the expense of the whole formation percolated, and similarly certain iron holding parts will become increasingly rich in iron. The mineral composition of the sediment becomes dissociated, and the individual mineral particles are separated from each other.

In this wise originate these concretions which may be regarded as phenomena typical of many of the India sedimentary rocks.

3. *Regur.*—The gneissic rocks at Torramangalam near Perambalur are covered by that mysterious black soil which is known as cotton soil, or Regur. Little gullies have been cut into it in every direction, and the sections show an unbedded dark black soil from 50 c. m. to 1 metre in thickness. Close to large gneiss rocks which stand up out of the level ground, the black colour decreases, and through the admixture of the light-coloured weathered gneiss the cotton soil changes into a grey earth. No red lateritic colouring was visible on the gneiss, but only a few kilometres further on high termites' nests built of red laterite were common enough under fig trees and casuarinas. As to the mode of formation of the Regur I have been unable to form a conclusive opinion. Perhaps the spreads were once swamps, such as are common in South India, whose peaty mass was subsequently desiccated. The assumption of a Loess-like origin for the Regur appears to me an improbable one.[1]

[1] Dr. Walther would appear to be unacquainted with Hislop's theory of the subaërial origin of the regur, which is now generally accepted by Indian Geologists as the most satisfactory explanation of the formation of this wide-spread form of soil. If Hislop's theory that the regur is an old forest humus be admitted, it becomes easy to understand how it can stretch unchanged over contiguous rocks of the most varied character, as the Dharwar and Deccan traps, granites, gneisses, limestones, quartzites, schists and shales, modern laterites, and alluvia, and how it can have been formed on the tops of many small isolated plateaus where the existence of lagoons was a physical impossibility. The question was ably discussed by Mr. W. T. Blanford, F.R.S., in the Manual of the Geology of India, pt. I, p. 432.

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4. *Blown Sands.*—It is known, through Foote's investigations, that large areas in South India are covered by beds of blown sand. High dunes are there met with, of which the so called "teris" appear to deserve more special attention. These are sand hills of intensely deep red or brown-red colour which occur on the South Indian coast from Tutikorin to Carricall[1] and give the landscape an uncommonly strange appearance. As I easily satisfied myself Foote's views regarding them are perfectly correct, namely, that the red colour added to the sand of the dunes, is nothing more than laterite dust, which the monsoon winds have mixed with it, and thus given them so typical a colouring that one might believe oneself to be looking at a sandstone weathered into red sand. (The red colouring which the river sands of the Sone, the Cauvery and other Indian rivers show, appears to be due to similar processes.) "Teri" sand appears also on Rameswaram island, in several roadside sandpits between Paumben (also written Pambam or Paumbam) and the town of Rameswaram.[2] As a great part of the island, and particularly the long spur stretching away to Thanus Kodi point, consists of light-yellow blown sand, it would appear that at present the monsoon can no longer convey the laterite dust as far as the island.

[1] Dr. Walther has here fallen into an error as to the distribution of the "teris" or red blown sands, which according to him lie along the coast between Tutikorin and Karikal. Those that I am acquainted with in the south of the Peninsula, and have described in my Memoir on the Geology of Madura and Tinnevelly Districts, and in a paper on the Geology of South Travancore, in Vol. XVI of the Records, Geological Survey of India, all lie near the coast (but never actually touching it) beginning from a point 20 miles west of the Pamban Channel, and extending round to a point near the coast of South Travancore, some 26 miles north-west of Cape Comorin. I am unaware of the occurrence of any true teri sands on the east coast of Madura (Palk's Bay), and I certainly met with none in the south or east of Tanjore District. To my apprehension the true teris cannot be traced within 20 miles of the Pamban Strait, and the rusty-coloured sand seen in sandpits along the road between Pamban and Rameswaram town, is not a true red-coated teri sand, derived from the inframontane band of red loam, but common sand formed of discoloured quartz.

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[2] Here, again, Dr. Walther has understood my description of the origin of the Teris in quite a different sense from that I intended to convey. I do not regard the teris as coast dunes, merely discoloured by a lateritic sand being blown on to them; on the contrary, I regard them as of totally distinct origin. The true coast dunes are formed entirely of sand thrown up on the beach by the heavy surf which breaks incessantly on the coast. They contain a very large, but equally variable, percentage of comminuted shells mixed with the ordinary drab or buffy quartz sand, but containing also a perceptible quantity of garnet and magnetic-iron sand equally blown up from the beach. The teris, on the contrary, consists entirely of quartz sand, coloured, red externally by a coating of red loam, but limpid if washed with dilute acid. I examined many samples from many teris most carefully with a powerful lens, but in none did I discover any other mineral, though I fully expected to find comminuted garnets in great quantity because of the immense number of small garnets included in many of the gneissic beds forming the Southern Ghats and their spurs, and from the outliers of which the teri sand must have been originally derived. The teri sand has derived its red colour from the deep red loam formation, which forms such a remarkable band along the foot of the Southern Ghats. The surface of this red loam is scored by the heavy westerly gales of the summer monsoons, carried eastward or north-eastward, and dropped near the coast, but not, except in a few places, in actual contact with the coast dunes. It is only where the contact takes place that the Teri

II.—ADAM'S BRIDGE

From Cape Tonitürei to Manar extends a sand barrier which is recognized by its structure and origin as a formation thrown up by the storm-driven surf waves, a formation which is of equal interest to the lover of old Indian myths, as to the Geologist and the student of the geographical distribution of animals Indian legends tell of the building of this land connection between India and Ceylon, and historical accounts relate that it was severed again during the middle ages, while the geologist recognizes the fact that this process of the destruction and reconstruction of Adam's Bridge had already once before taken place in long past prehistoric times. The seas between Ceylon and India are shallow, and only vessels of small draught can navigate them [1] From May to October the south-west monsoon waves break against the bridge, and from November to April the north-east monsoon brings its waves here, and creates such a constant current, that at Tonitürei point,

sand gets mixed for a little distance with the beach sand, and so comes to contain comminuted shells

The absence of garnets is certainly a remarkable fact and as yet not satisfactorily accounted for I have not had an opportunity of examining the constituents of the red loam at the foot of the Southern Ghats since observing the absence of garnets from the teri sands, so am unable to assert or deny the presence in it of garnets. Possibly the ferruginous materials among the original constituents of the red loam have been entirely decomposed and are therefore no longer to be distinguished from the general mass of the loam in which the far more durable grains of quartz are included

The source and the age of the great red loam band which forms so striking a belt along the foot of the Southern Ghats have yet to be ascertained, the high ranges and the infra montane tract not having been geologically examined as yet It is very likely they may contain beds even richer in iron than the garnetiferous and hornblendic beds which they are largely made up of They were too densely covered with forest, in most parts, to allow me to gain anything like a complete idea of their structure from a mere rapid traverse of the Mahendragiri plateau and other parts By far the greater part of the red loam band lay outside of the area examined by me, and there is yet much to be learnt about it.

There is much also yet to be learnt as to the peculiar distribution of the teris with reference to the coast dunes but this can only be learnt by residence near them and the coast during the south west monsoon. From the little I casually observed during a brief visit to Kutalam in 1869 (when I was practically unacquainted with the Teris themselves) I think it will be found that the location of these red sand hills is mainly due to the action of the southerly or easterly sea-breeze which meets the red-sand laden west wind in the afternoon or evening and makes it drop its burthen by cooling it The westerly wind appears to carry the red sand in direct proportion to its own heat The extraordinary display of flamelike dust clouds such as I described in my Madura Tinnevelly Memoir (p 86, Vol XX, pt 1, M G. S. I) only took place during the great heat of the afternoon after the wind had acquired a high temperature. Much red dust falls into the sea, but on land the fall does not appear to take place till the sudden inrush of the cool evening sea breeze sets in

My actual study of the teris all took place during the north-east monsoon month, and I had no opportunity of studying the effects of the westerly winds on the coast The action of the north-east monsoon on the teris seemed inappreciable, the breezes being, as a rule, quite gentle, but when the north-east wind is violent the coast dunes are wet either from rain or from clouds of spray, and the sands are immoveable.

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[1] Preliminary steps have been taken towards the cutting of a ship canal across Rameswaram island, which will allow of large ships avoiding the long voyage round Ceylon.

the sea races to the south with a great current like a rapid mountain stream and a perceptible fall of several feet. It is quite easy to understand that both these antagonistic movements must pile up great masses of sand at the narrowest part of the strait, and equally so to explain that a raised sand-bank might have been formed, and thus a perfectly unbroken bridge from India to Ceylon maintained perhaps for a short time, which would be of very marked importance for the migration of animals to the great island. It is a remarkable fact that corals live nowhere on the sand-bank itself, though the surrounding seas contain many coral reefs, and Rameswaram island itself is edged by a fossil reef. It would even appear that the original Adam's Bridge showed a gap in place of the present island of Rameswaram which gap was closed later on by the growth of the coral reefs. And when the communication between the Indian Ocean and the Bay of Bengal was thus interrupted the waves sought another passage and again destroyed the sand.

It appears to me that at the present day more is being destroyed than constructed in Palk's Strait, for the sand bridge is everywhere showing scarps and well-exposed sections. In contrast to the well-bedded sediments found at the bottom of the sea, or in the inundation areas of great rivers, and in contrast to the typical discordant parallelism of structure, or diagonal bedding, shown by unfossiliferous æolian sandstones, a sedimentary deposit is formed, in the surf zone of the sea coast, whose structure must be designated as irregular bedding, as it is a strange intermediate between bedding and diagonal (false) bedding. If one considers what strange changes sandy coasts undergo through surf-action, how they are now worn away, then washed up again, now piled up, and then again undermined so that they crumble down, one can understand that in the domain of the surf a sediment is formed in which no regularity of structure is recognizable, and in which all types of sedimentary structure may occur. Such is the building up of the Adam's Bridge. But what is most striking in these sections is, that a great part of the same consists of small and great blocks of sandstone which being cemented together by a sandstone matrix form a giant conglomerate. We must conclude from this that Adam's Bridge existed once, a long time ago; that it was destroyed by unexplained causes, and that the fragments were again re-cemented only to be broken asunder again in the beginning of the fifteenth century. We thus learn from the sections that a land connection between India and Ceylon existed twice, and has been twice interrupted, and that more than one migration of the fauna from India to Ceylon could have taken place.

III.—Marine Sediments.

1. *Living coral reefs.* The reefs of Palk's Strait and the Gulf of Manar present a totally different aspect from those of the Red Sea, as Madrepora Corymbosa, which is so common there, is a rarity in the Indian Seas. The genus which determines the character of the Indian reef is Porites, which attains to an immense development. Masses of Porites, two metres in height, and five metres in diameter are by no means rare, and by the side of these tower-like massive forms the branching Madreporidæ, the Pocilloporidæ, &c., appear to be nowhere. Nearly all the Porites are dead at their summit, and growing only along their periphery. As the ebb-tide falls considerably here, and uncovers great areas of the reefs, it is quite possible that the summits of the corallites died from this cause; but I saw many cases of Pocillopora corallites stand-

ing 4 centimetres over the water without its appearing to injure them. As Professor Möbius has observed, and as I have been repeatedly able to confirm, corals secrete during low ebb-tide a great deal of mucus which covers the whole corallite and protects it from drying up. When corals are taken out of the water this mucus drips from them for a long time and in considerable quantities.

Between the Porites "towers," and the branching growth of the smaller corallites, a calcareous sand is formed filling up the spaces, to which many impurities are added, and which is mostly of grey colour. With the flood-tide the water became rather turbid, but I could not observe that it was directly injurious to the life of the corals.[1] The genus Porites at least seems unsusceptible to the turbidity, but perhaps the smaller number of species of the other genera may be explained by its existence. At Shingle island a breakwater composed of broken coral branches rises $1\frac{1}{4}$ metre above the level of the sea. The reefs around Currysuddy island were exposed to a depth of 30 centimetres at ebb-tide, and appeared to be mostly dead, from which I incline to infer that the negative displacement of the strand indicated by the sub-fossil reefs continues to the present day.

Here, as everywhere, the calcareous algæ play a great part in the living coral reefs. It is, thanks to them, that the dying and dead corals are encrusted with lime and cemented together. By this service they become as important for the structure and formation of the reefs as the corals themselves. After much cruising about in vain, I succeeded in finding near the east-cape of India[2] a considerable colony of Lithothamnium at a depth of 2·20 metres in the middle of the fringing reef. All the specimens brought up by my divers were grown on branches of coral. The mass of the algæ attained to pretty considerable dimensions. Tridacna was not seen by me. Foraminiferous sands, such as are so common on the Red Sea reefs, I also failed to observe, and altogether pelagic life, with the exception of innumerable physalia, and some janthinas, spirulas and nautilus shells, appeared to me rather poor. A whale, 6 metres long, had been drifted on to the north coast of Rameswaram.

2. *The Sub-fossil Reefs.*—Around the coast of Rameswaram, on the west, north and east sides, occurs a terrace two metres in height which has been destroyed by the surf in various places, but always re-appears again after short interruptions and continues its course as a uniform band. On the opposite Indian coast the same terrace is recognizable at Tonitureì point, but the view that it must here be regarded as a fossil coral-reef is incorrect, as the sandstone there contains but few coral fragments and nowhere any entire corals. But its occurring at the same level above the sea, and the intercalation of similar sandstones in the sub-fossil reefs of Rameswaram, appear to justify one in regarding the two formations as synchronous, as was

[1] Where the porites corallites grow with flattened, often melon-shaped tops, they appear to suffer a good deal from the precipitation on them of the suspended clayey matter causing the turbidity of the water, and the polypes on the flatter parts are killed. This I noticed in many instances on the fringing reef near the Pamban lighthouse, and in all cases where this had happened, a small deposit of very fine mud lay on the surface. Where the corallites had grown into more pointedly mamillate shapes the precipitated mud had found no resting place and the polypes were flourishing.

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[2] By the east cape of India Dr Walther presumably means the Tonitureì spit.

done by Foote in his map.[1] For not only do the sandstones and coral limestones appear as heteropic sediments, but the fossil reefs themselves show such a change in their petrographic quality, that one would have to regard certain contiguous parts as totally distinct and varied formations if their continuity and synchronism were not placed beyond doubt by an investigation of the locality.

Foote regards the "reef" band as sub-fossil, and after seeing the hardly altered corallites on the west side (of the island), and studying the reef of Currysuddy island which are still standing in the sea, but have lately died, no further doubt can exist that the "reef" band, now raised 2 metres above the level, is a very recent formation.

It would appear that the coral fauna of the fossil reef is identical with that of the living one, but nevertheless I endeavoured to make as complete a collection of the fossil corals as possible, as the recent fauna is being very thoroughly worked out by Dr. Thurston in Madras. Perhaps on completion of his monograph it will be feasible to give an exact opinion on the near relations of the two faunas. As on the living reef, so also in the fossil reef on the western coast, do the great colonies of Porites occur frequently, and attain to a height of 2 metres and a diameter of 5, and stand up on exposed parts like old watch towers. Not only the edge of the coast consists of coral, but also a great part of the land itself, for a lagoon in the interior of the island (the remains of a former atoll-lagoon) is connected with the beach by a channel some 500 paces in length, which, for nearly the whole of its length, runs through a coral breccia, enclosing a rich molluscan fauna.

On the north coast (a short stretch of which I was unable to visit), the same barely altered materials are met with in the reef, and on the north-east coast large land shells occur very numerously among the corals, which shells must have been washed into the sea by violent rains and have drifted out to the reef when forming. A remarkable change is observable in the character of the uniformly continuous reef soon after passing this point; instead of the friable. loosely-cemented coral breccia, the reef on the east coast shows a dense rock ringing under the hammer, and consisting of coral fragments so densely cemented by a red medium that one appears to have a red and white mottled Alpine limestone before one.

In the extension of the "reef" band towards the great temple, the structure of the reef changes yet once again, and in place of the red marble, appears a limestone consisting entirely of calcareous algæ (Lithothamnium) with a few scattered coral masses. To the south of the temple appears blown sands which make up the rest of the coast.

About a kilometre inland, from the fossil algæ bed, quarries have been opened in which again another variety of reef rock is exposed. Instead of the brick red cement of the coast, the coral branches are here covered by sinterlike grey encrustations which cement them together.

We find thus among the sub-fossil, synchronous coast formations of Palk's Strait, a great variety of heteropic sediments, which in some places are hardly changed, and at others strongly metamorphosed, and deduce from that the fact that the metamor-

[1] Memoirs of the Geological Survey of India, Vol. XX, pt. I, "Geology of Madura and Tinnevelly Districts."

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phosis of such rocks is not a general process, but only a local one induced by local and temporary causes.

3. *The Reef-rocks of the Cretaceous age.*—On looking north from the high pagoda-crowned Trichinopoly rocks, a group of hills is seen rising from the wide level plain, which hills [1] belong to the upper cretaceous system whose rich fauna is well-known through the labours of Blanford, King and Stoliczka. Blanford's statement that imbedded coral limestones occur in that quarter induced me to examine it rather closely, and to look up all the coral limestones indicated on his map.[2] The kindly recommendations of Mr. Collector Fawcett to his village headmen rendered my bullock cart journey through those out-of-the-way villages very materially easier, and I was everywhere received in the most friendly and most original way.

I wished to begin my studies at Cullygoody and end at Utatur, but the utter ignorance of my drivers took me already in the first night in a completely wrong direction, and in order to avoid repeating a ten hour's journey, I commenced with Utatur and reached Cullygoody eight days afterwards.

At Utatur resting on the granite are sandstones with diagonal bedding which pass up into marls rich in gypsum Saurian bones of great size and fossil wood are the only fossils of these beds. Over them lies a bedded limestone which passes locally into massive unbedded calcareous rock, and which at several points rest directly on granite rocks without any intermediate beds of sandstone or marl. Individual granite blocks are cemented into the limestone. This limestone, which Blanford designated as a coral limestone, has been strongly metamorphosed, and no fossils are to be seen in it except spherical outlines the size of a head which might possibly be thought to represent former corals.

Per contra, the coral limestone at Maravattur, which appears to rest directly on the granite, is very rich. Individual beds are cut up by planes of bedding, as may be seen in a small quarry shortly before reaching the village. Nearly every limestone block shows corals on its surface, and a number of these are well-preserved although the matrix is crystalline,

Between Puially and Maravattur, Blanford has also indicated coralline limestones. Although corals occur here pretty numerously, I should hardly like to call this bed a reef, as the corals belong generally to small encrusting species which are included in the bedded limestone.

At this latter place I had already been struck by displacements of bedding of the cretaceous rocks, which had every character of dislocations, and which I could not explain as original structures.

When I reached Cullygoody, a few days afterwards, in order to study the coral limestones there, I again found a strong southerly dip of the thick limestone beds (which had been everywhere admirably opened out to supply materials for the

[1] The cretaceous rocks do not themselves form any elevations high enough to deserve the name of a group of hills as seen from Trichinopoly rock. All the heights visible from that distance are composed of gneiss.

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[2] Memoirs of the Geological Survey of India, Vol. IV, pt. I. Report on the Cretaceous Rocks of Trichinopoly District.

building of a new Mission Church). Neither the disposition of the bedding, nor the structure of these detritus-formed, brightly-mottled limestones appear to me to justify Blanford's assumption that they are original encrusting beds of a coral limestone. I prefer rather to regard them as dislocated limestone beds which cannot be accepted as typical reef-limestones.

While the various limestones described differ in no respect from such rocks in the north, I was struck by a speciality (already named above) in the accompanying marl beds of the Trichinopoly cretaceous area; namely, the wealth of concretions. Just as in the Ganges deposits, and in the laterites, so here in the marine marls, occur concretions from the size of a nut to one metre in diameter, and of all shapes, sometimes as true septaria and at others without internal septa, in such numbers that I cannot but see in them also a formation that has come to pass under the influence of the tropical climate. My reports on the occurrence of thick graphite veins in the laterite of Ceylon, on the biological conditions of living coral-reefs, on the structure of sections through the sub-fossil reef, on erosion phenomena on the Indian coast and on other series of observations can only appear at a later period.

Report *on the* Coal-fields *of* Lairungao, Maosandram, and Mao-be-lar-kar, *in the* Khasi Hills, *by* TOM D. LATOUCHE, B.A., *Deputy Superintendent, Geological Survey of India.* (With 3 Plans.)

I.—THE LAIRUNGAO FIELD.

Position of the field.

This coal-field, which is of considerable extent, is situated on the Shillong-Cherra Punji cart-road, which enters it at about 26 miles from Shillong and 7 from Cherra. Its northern edge extends along the face of a steep scarp, about 200 feet high, which crosses the cart-road one mile south of the village of Serrarim, and from the top of which an undulating plateau slopes gently to the south, where it is deeply indented by the feeders of the stream that occupies the gorge east of Cherra Punji. Near the northern edge of this plateau is situated the village of Lairungao, whence the field takes its name, and from which there is a gradual descent, followed by the cart-road, to the Cherra plateau. Coal is exposed in numerous places both on the northern face of the hill, and in the ravines to the south and south-west of the village, all the outcrops which I could discover being marked, with the thicknesses of the seam observed in each, on the accompanying plan. Indications of coal also occur, on the same horizon, in many places outside the limits of the plan, but in all cases in which I investigated these, the seam was seen to have thinned out to an insignificant string a few inches in thickness, and quite useless.

Comparison with the Cherra Punji coal-field.

The conditions under which the coal occurs are very similar to those at Cherra Punji; in fact, many indications of coal in the same position with regard to the accompanying rocks are seen in the intervening area, and there can be no doubt that the seam once extended over the whole distance, large portions having been washed away since its

deposition. The coal at Lairungao, however, does not appear to be so good in quality, generally speaking, or so evenly distributed, as that at Cherra. This portion of the original field probably lay nearer the edges of the basin of deposition, as is shown by the thinning out of the seam in various directions, and so there was a larger admixture of foreign matter, mud, &c., with the vegetation that formed the coal. Portions of the seam, however, appear to be quite equal in quality to the Cherra coal, and I think that a large proportion of the coal that can be extracted would be found good enough for all practical purposes. It would be interesting and not difficult to make a few experiments on this coal, in comparison with that from Cherra, in the engines on the Cherra-Companyganj State Railway, in order to determine its steam-producing and other properties.

Mode of occurrence of the coal seam.

The coal seam, with the whole of the rocks in which it lies, dips with a very slight angle to the south. The limestone beneath it is not nearly so highly developed as at Cherra, and is occasionally entirely absent, so that none of the "swallow-holes" so frequent there, are found in this field, nor do the beds appear to have been faulted or disturbed in any way. Sections which show anything more than the seam itself are few, but it can be seen that the floor of the coal is a bed of grey carbonaceous shale, about two feet thick underlaid by sandstone, and the roof is a thick bed of white or buff sandstone, which is very soft where it has been exposed to the air, but no doubt is harder further in, and would stand as well as that above the seam at Cherra. A section through the seam on the face of the scarp east of Lairungao village, where the whole thickness is eleven feet six inches, gives the following succession in descending order:—

	Ft.	In.
Soft, white, or buff sandstone	...	...
Carbonaceous shale	2	6
Soft, white, and buff sandstone	10	0
Coal irregular, about	1	0
Shale, very carbonaceous towards the base with lenticular layers of sandstone	6	5
Coal	4	0
Carbonaceous shale	2	0
Sandstone	...	...

The six-foot bed of carbonaceous shale, which makes up the greater part of the seam, would probably not be worth mining, but it would form a good roof to the galleries in the four-foot seam beneath it, and might improve further in. In the outcrops on the other sides of the field it does not appear, the sandstone coming immediately above the coal; but in most of them a bed of shale, a few inches thick, which may represent it, occurs about the middle of the seam, which would have to be worked out with the coal and picked out by hand afterwards.

Estimated quantity of coal.

On the whole, I do not think it would be safe to estimate the average thickness of the seam over the area, under diagonal lines on the plan, at more than three feet, which would give in round numbers a total of 1,500,000 tons of coal in the field; a considerable quantity of this would be worthless owing to the presence of the band of shale abovementioned, so that I think 1,000,000 tons might be safely put down as the total quantity available.

Methods of mining.

It would be possible to mine this coal in the same manner as that recommended in the case of the Cherra coal-field, namely, by driving parallel horizontal galleries in from the outcrop and working out the coal between them; but, except on the southern side of the field, I do not think this plan would be the best, as the coal would have to be carried to the top of the hill, before being sent down to Cherra. A better plan, I think, would be to sink one or more shafts at or near the village of Lairungao, so that the coal could be at once raised to the top of the hill, whence it could be easily taken by a light tramway laid along the cart-road to Cherra. This would entail the use of machinery, though it need not be of an expensive character, as the shafts need not be more than 100 feet deep. Adits might be driven from the bottom of these to the ravines on the south in order to drain the mines, and the coal might also be drawn out through them, and taken to the cart-road lower down. Taking into consideration, however, the increased expense and the greater distance from the plains, combined with the thinness and poor quality of the seam as compared with the Cherra coal, it does not seem probable that this coal could be worked with profit, at any rate until the sale of coal from Cherra has reached large dimensions, and a regular market has been established; or until that field begins to fail, which is not likely to occur for many years.

Concluding remarks.

Very little of this coal has yet been extracted, but the outcrop has been quarried to a small extent at a few places, and the coal sent in by cart to Shillong, mainly, I believe, for the use of the Public Works Department. There seems to be no reason, however, why this coal should not be brought into Shillong at a cheaper rate than that from Mao-be-lar-kar near Maophlang, for though it is somewhat further away, it lies directly on the cart-road, whereas the coal from Mao-be-lar-kar has to be carried by coolies five miles across a gorge 1,000 feet deep before it reaches the cart-road at Maophlang. The villagers of Lairungao, to whom the coal-field belongs, do not appear to have ever thought of carting the coal to Shillong and competing with the owner of the Mao-be-lar-kar coal, who has a practical monopoly of the trade; which, it must be said, is a very small one.

II.—THE MAOSANDRAM FIELD.

Position of the field.

This little field occupies the summits of three small knolls, about a mile and a half north of the village of Maosandram, which lies on the narrowest portion of the ridge separating the Bogapani gorge from that of the Um Gni, a considerable stream issuing into the plains about 12 miles west of Chela village. It lies on the path from Chela to Maophlang, and is about 14 miles in a direct line south-east from the latter village. The coal has been worked to a small extent to supply fuel for lime-burning, as a bed of limestone is irregularly developed beneath the seam in a similar position to that at Lairungao and Cherra; but otherwise the field is unimportant, as it lies at a great distance from any good road, and the coal seam is not a thick one and is poor in quality.

Quantity of coal available, &c.

As will be seen from the annexed plan of the field, the seam attains in one place a thickness of 7 feet, but a good deal of this is very shaly stuff and I do not think that the average thickness of good coal over the whole area, 857,000 square feet, can be estimated at more than a feet, which gives a total quantity of about 63,000 tons of coal in the field.

It has hitherto been worked in open quarries, and as the seam lies very near the top of the knolls, this is the most economical way of obtaining the small quantity used in lime-burning; and it is hardly likely, considering the distance of the field from any possible market and its limited extent, that this coal will ever become useful beyond supplying the small local demand.

Geological age.

The beds that accompany the coal are quite similar to those at Lairungao and Cherra, and the coal is of the same geological age, the Eocene or most ancient epoch of the Tertiary period, as at those places.

III.—THE MAO-BE-LAR-KAR FIELD.

Position of the field.

This field, though of still smaller extent than that near Maosandram, is of greater importance, as it has supplied the station of Shillong for many years, and still continues to do so, though the opening of the cart-road to Cherra has made the Lairungao field more accessible, even considering the greater distance of the latter field from Shillong.

It is situated close to the old road from Maophlang to Cherra Punji, at about five miles from the former village and 19 from Shillong, near the eastern edge of the deep gorge of the Bogapani river, which runs between it and Maophlang The coal has to be carried by coolies across this gorge, about 1,000 feet deep, before it can be loaded into carts, which adds much to its cost in Shillong.

Age and mode of occurrence of the coal-measures.

The coal-measures, which belong to a geological epoch, the Cretaceous, older than that of the fields at Cherra, Lairungao, &c., appear to have been deposited in a small bay hollowed out of the still older quartzites, which form the greater part of the neighbouring country, a rib of which is seen at the surface at the northern edge of the field, where the coal-measures are suddenly cut off by it. On the other sides, to the south and east, the seam of coal, which is tolerably thick near the quartzite rib, thins out and becomes very shaly, eventually dying out altogether. Where the seam is best seen, at either side of the ridge on which the village of Mao-be-lar-kar stands, it is from 8 to 9 feet thick, but only the lower portion of this, about 3 feet 6 inches thick, is good coal, and has been worked. A vertical section through the beds on the east side of the ridge is as follows:—

	Ft.	In.
Yellow and white sandstone, about	20	0
Coal, shaly, with much pyrites	2	6
Carbonaceous shale	3	6
Good coal with layers, containing much pyrites	3	6

The section at the western side of the ridge is quite similar, the good coal being 3 feet thick. A few galleries have been driven into the coal from either side, but have not penetrated through the ridge, and from these the coal is at present extracted. Other portions of the field have also been worked as open quarries; but the soft sandstone above the coal is very liable to fall after being exposed to the air for some time, and all these workings are now abandoned.

Quantity of coal and probable duration of field.

A moderate estimate of the quantity of coal in the field, that is, over the area under diagonal lines on the plan, gives a total of about 52,000 tons, which will supply the demand in Shillong, and this is not likely to increase much for many years.

I was informed by the owner of the mine, who lives in the village close by, that from 10 to 12 maunds left the mines daily, and perhaps more in the cold weather; but even taking the quantity extracted at as much as 20 maunds daily, the field should last for the next 200 years.

General remarks.

The coal of this field contains a considerable quantity of iron pyrites, which would render it unfit for use in steam-engines, as the sulphur which is one constituent of the pyrites, combines with and destroys the furnace bars. It has the same effect on the bars of ordinary grates, but does not destroy them so quickly, as the heat produced in them is not so great. Otherwise the coal is very suitable for household purposes, as it burns readily with a good flame, and it would probably yield a very fair quality of gas, if this is ever introduced at Shillong. The Lairungao coal, however, which does not appear to contain so much pyrites, would probably be better in this respect; and if a large supply were required for this purpose, it could probably be obtained at less cost from that coal-field or from Cherra Punji.

Further Note on Indian Steatite;[1] *by* J. R. ROYLE, C.I.E., *India Office, London.*

In the furtherance of an endeavour to meet a demand for fine steatite for the manufacture of gas-burners in England, the subject was taken up by the India Office in connection with the Colonial and Indian Institute. Enquiry was instituted, through a despatch from Her Majesty's Secretary of State for India to the Government of India, as to the quality and value of Indian stone suited to the purposes required.

A very fair knowledge of the ordinary features of stone from various parts of India had already been acquired by the Survey, while certain localities in the Madras Presidency were known as yielding very good stone. New specimens were, however, sent down to the Survey from different districts, the Madras Government arranging, in the first instance, that their then Mineralogist, Mr. Bosworth Smith, should make preliminary trials of the stone from that Presidency as far as means were at his disposal.

A more elaborate series of experiments was then instituted in the Survey laboratory by Mr. F. R. Mallet, on which he reported in his *Note on Indian Steatite*, published in Vol. XXII (1889) of these Records, in which, also, he embodied Mr. Bosworth Smith's notes.

Mr. Mallet, after trial of the specimens from the Madras Presidency, the Central Provinces, Rajputana, and Burma, came to the general opinion that "although the final selection of the most suitable material must be left to the gas engineers themselves, it will, I think, be found that the variety like A 1, from Maddawaram in Kurnool, and the stones from Gulumari in the Anantapur district, and Raiwala in Jaipur, are among the best, while several other samples appear to be very promising."

All the specimens were then despatched to the India Office for further treatment, the results of which are given in the following "Memorandum on Indian Steatite" by Mr. J. R. Royle, C.I.E., of the India Office, in communication with Sir G. Birdwood, K.C.I.E., C.S.I., &c.

In accordance with your instructions, on receipt of the specimens of steatite referred to in the letter from the Government of India, No. 2 (Museums and Exhi-

[1] See Records, Geol. Sur. of India, XXII, p. 59.

bitions), dated 2nd April 1889, and fully described in the Memorandum by Mr. F. R. Mallet, I made the necessary arrangements with the Stores Department, and personally superintended the cutting up of the specimens at the Stores Depôt, Belvedere Road.

The circular saws and appliances at the Depôt, being mainly intended for use in the manufacture of packing-cases and similar rough work, are not suitable for any delicate experimental work, but they sufficed for cutting from each original block a few sample slabs for distribution.

The whole of the samples were then arranged for inspection at the India Office, and Mr. Sugg (of the firm of W. Sugg & Co., Gas Engineers, at whose request the specimens were originally asked for from India), was then invited to call and see them. He selected seven (out of the twenty-two sent from India) as being worth experimenting on, with a view to testing their suitability for the manufacture of gas-burner tops. The remaining samples were pronounced not suitable for the purpose required, either through their being manifestly too full of hard and gritty specks or crystals, or through being too flaky to stand manipulation.

The samples selected for trial were—

New Mark.	Old Mark.	Locality.	Remarks.
A	A 1	Maddawaram Kurnool	This sample was finally approved of by Messrs. Sugg.
B	A 2	Maddawaram Kurnool	
C	B 1	Pendakallu Kurnool.	
D	B 2	Pendakallu, Kurnool.	
L	L 1	Pathur N. Arcot	
R	None	Mora, Jaipur	
S	None	Mora, Jaipur.	

Messrs. Sugg's report on the samples experimented with is appended, and a specimen of a perfect burner top made from sample A, as well as a damaged burner top from sample R, showing how a slight flaw in the material makes it unsuitable for working, are also forwarded herewith.

As a result of their examination, Messrs. Sugg ask that a trial consignment of five tons of the steatite, sample A (A 1 in Mr. Mallet's memorandum) may be procured for them in blocks averaging six inches cube. The probable cost of this variety, which comes from Maddawaram village, Nandial taluk, Kurnool district, is estimated in Mr. Mallet's memorandum to be about 3*l*. 7*s*. to 4*l*. per ton delivered in London, but I explained to Messrs. Sugg that it was impossible to quote a firm price until a regular trade in the mineral was established, and that, seeing that the first order was so small, the cost of a trial consignment would almost certainly be increased owing to the initial expenses of selecting suitable blocks of stone. They have consequently agreed to pay up to 10*l*. or 11*l*. per ton for the five tons ordered, to include delivery at their works, but they ask that the cost may be kept as low as possible, and that, if the material can be supplied for less than their limit, they may have the benefit of the lower price.

So far as it goes this is satisfactory, but it is evident that so small an order as five tons, or even the possible ten tons a year which Messrs. Sugg might eventually

consume for gas-burner tops, is of little use alone for establishing a trade with India in the material, and if this is to be done a more extended use for it must be found. Messrs. Sugg are confident that there must be many uses for it if it can be procured at a reasonable price, but it has not been possible as yet to arouse much interest in the subject, although numerous letters with invitations to inspect the samples have been addressed to makers of gas-fittings, gas-stoves, gas-engines, acid pumps, fire-proof paints, lubricating materials, makers of toilet powders, and others, while attention has also been drawn to the subject by the editor of a paper devoted to the gas and water interests.

Since the receipt of Messrs. Sugg's order, endeavours have been made to obtain further orders for the same variety as that they have selected, but as yet without success, although a maker of toilet powders and soaps, and of a preparation used as a desiccant by medical men, under the name of *Terra Cimolia lævigata*, or "White Fuller's Earth,' has pronounced this variety of steatite to be good enough to replace a variety which now costs him about 30*s.* per cwt.

But the total quantity required for this purpose annually is very trifling, and the same may be said with regard to the requirements of the various branches of the gas-engineering trade.

It has been ascertained that about 90 per cent. of the steatite at present imported into England from the Continent is in the ground state, in which condition it is used by various trades. It is estimated that about 3,000 tons of different varieties of steatite are at present imported annually, and of this quantity probably about 100 tons only are in lumps or slices.

Good crushed steatite may generally be purchased at from, say, 50*s.* to 80*s.* per ton. Of course higher prices than the above are paid for small quantities for special purposes, but the trade in these special varieties is very limited.

It would appear, therefore, that there is really an ample supply of steatite of good quality already imported into England, and that the price of small lots for retail use—in which would be included the small quantities at present used for gas-burner tops—is, to a great extent, artificially kept up. One large importer of steatite, whose letter is appended,[1] remarks that "they (*i.e.*, makers of gas-fittings and toilet preparations) sell their articles at very high figures, and can afford it; therefore why should not the producer and merchant have a share of it?"

If we judge solely by this letter, it would seem hopeless for India to compete with other countries in supplying England with the crushed steatite, which is nearly all ground by water-power at the place of production; but it is clear that the importer in question is interested in keeping matters as they are, and is opposed to the introduction of any new supplies. It is, however, manifest that the average prices fetched by the ground material are so low that it could not pay to import from India solely for grinding, though if once there were a sufficient demand for the mineral in blocks, considerable quantities of small pieces and the *débris* from quarrying would be procurable at a very trifling cost, and could be utilised for packing around the blocks when shipping them to England.

In connection with the employment of crushed or ground steatite, it has been ascertained that shipments of this material have been made from this country to

[1] See No. 4.

Bombay; there is, therefore, probably some demand for it there, and it might be better to grind steatite of local production in Bombay than to continue to import it ready ground.

But it is evidently only in blocks or slices that its importation into this country from India can be really remunerative, and at present its use in this form seems to be very limited. Meanwhile Messrs. Sugg & Co. are anxious to receive the trial consignment for which they have asked as early as possible, and I would suggest that, if the Government of India see fit to comply with the request for five tons of the Madras steatite, an additional supply of one or two cwt. of the same should be sent to this office, and that on its arrival here the attention of all trades interested in the matter should be drawn, through a paper such as the Journal of the Society of Arts, to the opportunity afforded them of procuring good samples free, for experimenting with a view to a more extended use of this material.

J. R. ROYLE.

6th November 1889.

No. 1.

VINCENT WORKS, REGENCY STREET, WESTMINSTER;
2nd August 1889.

DEAR SIR,

In reply to your favour of the 1st instant, we enclose report showing result of our tests of the samples of steatite received from you, from which you will see that samples A and C are very good, particularly A.

Would it be possible for us to get five or ten tons of A for trial, and in what time could we have it after ordering?

Yours faithfully,

(Signed) WILLIAM SUGG & CO., *Limited.*

J. R. ROYLE, ESQ.

Enclosure in No. 1.

REPORT OF TESTS MADE WITH SAMPLES OF INDIAN STEATITE RECEIVED FROM MR. ROYLE.

Sample A.

Cut eight blocks for 5-feet T tops; burned well inside and outside, no waste, all good in slotting and screwing; eight good burners, all baked well.

Sample C.

Cut six blocks for 5-feet T tops; worked well, but rather gritty; slotted and screwed well; none bad; six good burners, all baked well.

Sample D.

Cut nine blocks for 5-feet T tops; rather flaky, but worked well; three blocks split and broke; six good burners; slotted and screwed well, not so good as samples A and C; baked fairly well, not so good as A and C.

Sample R.

Cut eleven blocks for 5-feet T tops; two broke in first process, one chipped in slotting; rather flaky, but worked well, no grit; slotted and screwed well, not so good as samples A and C; eight good burners; baked fairly well, similar to D.

Sample S.

Cut seven blocks for 5-feet T tops; three spoilt in first process, two chipped in slotting; two good burners; too flaky, but worked well; not so good as any of the other samples; baked fairly well.

Sample B.

Soft, but full of iron pyrites, too dangerous for tools.

Sample I.

Hard, and very dangerous for the tools; almost too hard for the saws.

No. 2.

VINCENT WORKS, REGENCY STREET, WESTMINSTER,
8th August 1889.

DEAR SIR,

We thank you for your favour of the 7th instant, and in reply beg to say that we should not mind giving 10*l.* or 11*l.* per ton delivered here for · sample five tons of this steatite, for trial. We cannot offer any higher price, as there is always a certain amount of waste which cannot be utilised, and which is not so good as the sample. Of course, if it could be procured for less, we should be pleased to have the benefit of the reduction. When our Mr. David Sugg had the pleasure of calling upon you, he understood you to say that this steatite was easily procurable, and, so far as selecting it was concerned, this did not appear to be very necessary, inasmuch as he understood that the quarry yielded a large stone similar to what he saw in your sample-room.

We trust there will now be no difficulty in obtaining this sample five tons, and, with regard to payment, we should be willing to pay for the material on delivery.

Yours, &c.,

(Signed) WILLIAM SUGG & CO., *Limited.*

J. R. ROYLE, ESQ.

No. 3.

VINCENT WORKS, REGENCY STREET, WESTMINSTER;
13th August 1889.

DEAR SIR,

In reply to yours of the 12th instant, we beg to thank you for the trouble you have taken to procure steatite for us.

We trust that the cost will be kept as low as possible, and, if the material can be supplied for less, we may have the benefit of the reduction.

There would be no hesitation in paying 10*l.* per ton if one could be sure of obtaining the quality approved of.

There should be a big field for this mineral, provided the price can be kept low. There must be numbers of articles which could be made out of steatite, such as ornaments for instance. The burner trade alone would not be sufficient to warrant a big trade with this mineral.

Again thanking you,

We remain, &c.,

for William Sugg & Co., *Limited*,

(Signed) DAVID W. SUGG.

No. 4.

LIVERPOOL;

29th October 1889.

DEAR SIR,

I have your favour of yesterday, and shall only be too happy to give you any information that shall lead to business to mutual advantage.

I note that you mention that the cost price laid down in London for the quality for grinding is 4*l.* per ton, but even so it is practically out of the market in comparison with other productions. For your information I send you herewith sample of steatite marked No. 54, which, including bags and everything, can be done here at your lowest point of 80*s.*, and this is as pure as you can possibly have the article. Of course it sells for something more than that figure, but at the figure named it can be laid down here, and in large quantities.

With regard to slices, you are quite right. Engineers have been accustomed to pay the figure you name, and why should they not? They only use a very small quantity. I suppose that 10 tons per year will cover the whole of the consumption for that purpose in England. That you see will never pay the miner, especially at the figure you put it down at; and if you think of encouraging shipments of the Indian article at the price you name, you will spoil a trade, and to no purpose.

There are other shapes and sizes which you have not touched upon, which also bring fair prices; but practically this is only a retail trade, and at present not likely to be of any size.

As to the toilet powder manufacturers, this is similar. The most insignificant part of the trade altogether, and what small quantity they do use it must be the very finest, and then they must pay a good price for it. They sell their articles at very high figures, and can afford it; therefore, why should not the producer and merchant have a share of it?

I can bring in steatite here of a very good quality, ground, bagged, and ready for consumption, at something like 50*s.* per ton. I can see, therefore, that it is quite impossible for India to try to supply this market in competition with other productions.

You are not perhaps aware of the fact that here, in our own country, we have a very fair deposit of steatite, but it has not been workable to any extent, because the article could not be transported to the mill and ground to compete with foreign production. I am going to make a further trial of it in my own mill; still, although I may do as well, I am not in hopes of doing better than I can do from abroad.

I may inform you that this is a trade in which I have been engaged for the last 15 to 20 years, and I am the largest importer of the article. This year alone I shall have run through something like 20,000 bags.

* * * * * * * *

Yours, &c.,
(Signed) GEORGE G. BLACKWELL.

J. R. ROYLE, ESQ.

Provisional Index *of the* Local Distribution *of* Important Minerals, Miscellaneous Minerals Gem Stones, and Quarry Stones *in the* Indian Empire, *by* W. KING, B.A., D.Sc., *Director of the Geological Survey of India* (*continued from p. 286, Vol. XXII*).

MADRAS.

IMPORTANT MINERALS.

Coal *C* Iron Ores, *I.* Gold, *G.* Petroleum, *Oil* Salt, *Sal.*

Mineral or Stone.	Locality.	Reference.	Other Minerals.	REMARKS.
COAL, *C.*	GODAVARI—	...	CLY. COR. D. GAR. GRT. LIM. LIR. PLM. Q. SAL. SND. TRP.	
	Beddadanol	Man. III, 71, Mem. XVIII, 195, Rec V 112; VII, 159; XV, 202.	...	38 miles W. N W. of Rajahmundry. The field was tested by boring, but without any good coal being found.
	Lingala	Man. III, 71; Mem XVIII; 194; Rec. IV, 59	...	Outcrops of coal in the Godavari river. Interest is again being taken in these outcrops by applicants for leases.

MADRAS—continued

IMPORTANT MINERALS—continued

Mineral or Stone.	Locality	Reference	Other Minerals	REMARKS
COAL, C.—contd	GODAVARI—contd			
	Maduveram (or Damarcherla).	Man III 71 Mem XVIII, 192 Rec. IV 59		A well defined coal field, mainly on the Nizam's side of the river on the Damarcherla side. On the British side, only 25,000 tons of coal are considered available fresh interest is being centered on this field 1890.
	MALABAR—Beypur . .	Madras Jour Lit & Sci XI 230 242 Cat of Minerals, Ores and Rocks, Mines, Central Museum, 1890 p 15	LTE . .	Lignite and igneous shale Also other places along the West Coast as far as Warkali in Travancore and northwards into South Kanara
	NILGIRI—Kunda Mts . . Ootacamund.	Man III, 120 Jour. Soc Arts, 1871, 201 266 District Manual, 96	CLY G GRT I LTE OCHR	Peat or turf Numerous peat swamps or bogs, utilised to some extent might be tried on proposed new hill railway
	Wainád . .	.	.	Many peat swamps The land of swamps
	NIZAM'S DOMINIONS—	See Nizam's Dominions.		Coal noticed incidentally here, as great part of the territory is usually talked of as in the Madras Presidency.
	Aksapur . . .	Man. III, 72 75		
	Antargaon . .			
	Alapali . .			
	Bundella . . .			
	Chinur . . .			
	Damarcherla . .			
	Kamarum . .			
	Sasti . . .			
	Singareni			Singareni is now in full working order, turning out over 100 tons a day
	Tandur . . .			

MADRAS—*continued.*

IMPORTANT MINERALS—*continued.*

Mineral or Stone.	Locality.	Reference.	Other Minerals.	REMARKS.
COAL, *C.—concld.*	PONDICHERRY— Bavur (Bahour)	Rec. XVII, 194	...	Peat. In the alluvium, at depths of 203 to 330 feet. Contains a very large percentage of moisture and ash. An attempt was made to work this deposit and compress its material into bricks, but the scheme fell through.
	SALEM— Shevaroy Hills	...	Ct. Grt. Lte.	Two peat swamps of good size, not used as fuel at present. R. B. FOOTE.
	SOUTH ARCOT— Tolum, ferry over the Vellar.	Man. IV, 253	...	A bed of peat is here exposed at ebb tide only. It consists mainly of leaves and fruits of dicotyledenous trees.
	TRAVANCORE STATE— Warakilli Quilon.	Rec. XV, 92–94.	...	Lignite, ligneous shale, trunks of trees. No value.
IRON ORES, *I.*	BELLARY— Copper Mountain range (2).	Rec. XXII, 27	...	These localities are numbered according to their importance. The district is immensely rich in hæmatitic ores of fine quality, all belonging to the Dharwar System. Smelting is carried on to a considerable extent at Kamalapur, Kannevi, Lalli, Siddagal and Marravanhalli. Many of the beds in the Sandur Hills are manganiferous. Ochreous beds of very varied colors are associated with iron beds. R. B. FOOTE.
	Kalhalli Sadda range (4).	R. B. Foote	...	
	Mallapanbetta range (3).	Rec. XXI, 51	...	
	Naddevi band (8)	R. B. Foote	...	
	Sandur Hills (1)	Rec. XIX, 104—107; XXII, 24—7.	...	
	Sindigiri Hills (7)	R. B. Foote	...	
	Teligi Hills (5)	Do. do.	...	
	Timlapur Band (6)	Do. do.	...	
	Yellapaduga Band (9)	Do. do.	...	

MADRAS—*continued.*

IMPORTANT MINERALS—*continued.*

Mineral or Stone.	Locality.	Reference.	Other Minerals.	REMARKS.
IRON ORES, *I.—contd.*	CHINGLEPUT . .	Man. III. 56; Mem X, 131. District Manual.	...	Many parts of the lateritic deposits are rich enough to give a fair quality of iron.
	COIMBATORE . . Bhavani Chennimalai. Kinattukadavu. Mulnur.	District Manual, 254 Balfour's Cyclopædia, Art Iron.	BRL. CLY GRT LIM NIT. Q. SAL, SOP.	The district has not been surveyed. Iron ores occur locally, and are smelted by the natives in some places, but no information is available as to the sources of the ores.
	CUDDAPAH—			
	Chintakunta . .	Cuddapah Man., 26		
	Chintulcherru . .	Mem VIII, 280		
	Nerrabyle.			
	Yerraguntla Kotta .	Man. III, 357.		
	GODAVARI—			
	Chittapuru . .	Man. III, 358 Rec IV, 114, V 26	.	Iron furnaces.
	Golapili . . .	Man. III, 358, Mem. XVI, 255	..	Ore derived from sandstones.
	Lutchmipuram . .	Man III, 358 Heyne's Tracts 218–225.	...	Furnaces.
	Polarum . . .	Man. III 358 Mem. XVI, 255		
	Rajahmundry . .	..	...	Ore derived from sandstone.
	Ramankapet . .	Man. III, 358, Heyne's Tracts, 218–225.	...	Furnaces.
	Tripati . . .	Man III, 358, Mem. XVI, 255.	...	Ore derived from sandstones.
	KISTNA— . .	...	CLY. D. GAR GRT. LIM LIB. PLM Q. SLT. SND.	
	Guntur . . .	Catalogue of Minerals, Ores, and Rocks, Madras Central Museum, 6	..	Silicious ore.
	Jaggaiapetta . .	Mem. VIII 294 .	...	The country north of the Traveller's Bungalow is covered with debris of very rich hæmatite which is smelted.

MADRAS—*continued.*

IMPORTANT MINERALS—*continued.*

Mineral or Stone.	Locality.	Reference.	Other Minerals.	REMARKS.
IRON ORES I—*contd.*	KURNOOL— . .	...	COP. D. GRT. LD LIM. Q. SLT. SND. SOP. TRP.	
	Bachapilli . .	Man III, 357; Mem. VIII, 277, 279, District Manual, 97.	..	Mostly hæmatite and specular iron ore.
	Gani Hill.			
	Golchinpollam .	Ditto.		
	Kuddaimal Kalwa .	Ditto.		
	Ramulkota . .	Ditto .	.	Gunnigal Hill, in the neighbourhood, is in great part made up of pure specular iron ore.
	Rudrar . . .	Man. III, 357; Mem VIII, 277, 279, also Madras Jour. Lit and Sci, XX New Series, 299.	..	In the Sirvel taluk Chief smelting place.
	Serinapur . .	Ditto.		
	Veldurti Hill.			
	MADURA— . .	..	GRT. LTF. SAL SND.	
	Kottampatti	Man. III, 347; Mem XX, 98.	...	The lateritic beds are remarkably rich in iron in many places.
	MALABAR—			
	Arakkaparamba .	.	...	Hæmatite in quartz. Not worked now.
	Chembrassin . .	District Man. II, ccclx and ccclxvii	..	Hæmatite and magnetite in gneiss.
	Kolangodu . .	Buchanan's Journey, II, 386.	...	Black magnetic iron sand.
	Kottayam Taluk .	District Man. II, cccxv.	...	Iron occurs in various parts of the Taluk. Not worked.
	Mangada . .	...	...	Lateritic ore. Mine abandoned
	Melattur . .	...	...	Mines abandoned.
	Nemini . . .	...	...	Magnetite in gneiss. Still worked.
	Pandikád . .	District Man. II, ccclix & ccclxvii.		
	Porur . . .	...	...	Magnetite in gneiss. Still worked.
	Tachambára . .	...	...	Still worked. Magnetite and hæmatite occur in the gneiss near this place.
	Vettatur . .	...	...	Mines abandoned.

MADRAS—*continued.*

IMPORTANT MINERALS—*continued.*

Mineral or Stone.	Locality.	Reference.	Other Minerals.	REMARKS.
IRON ORES, *I.—contd.*	MALABAR—*contd.*			
	Wainad Taluk . .	District Man., II, cccxxxii.	...	Iron occurs in various parts of the Taluk but is not worked. NOTE.—The Beypur Iron Works have been closed for many years. There is no iron ore at Beypur; it was only smelted there
	NELLORE— . .	...	CLY. COP. GAR. GRT. GYP. LIM. LTE. SAL. SND. TRP.	
	Chundi Hills . .	Man. III, 353; Mem XVI, 17, 21, 103		
	Gundla Kamma .	Nellore Man., 63	...	Magnetic iron beds of great size.
	Konijedu Ongole Shinampudi Tippa .	...		Magnetic iron beds of great size.
	NILGIRI—			
	Dodabetta . . Jakatala (Wellington) Karachola . .	Man. III, 352, Mem. I, 210, 248, Madras Jour. Lit and Sci. IV, 249.	...	Hæmatite, specular iron, and lateritic ore.
	NORTH ARCOT— .	Dist Man., 7 .	CLY. GRT. LIM. LTE. NIT. OCHR. SAL. SITE. SND. SOP. TRP.	
	Yerragutti . .	Heyne's Tracts, 189.	...	Iron is manufactured here from magnetic iron sand.
	PUDAKOTTAI STATE— Ayengudi . .	Man III 347, Rec XII, 147, Mem XX, 98.	...	The lateritic conglomerate around this place is remarkably rich in iron. The old smelting industry is quite extinct.
	Mallampatti . .	...	...	A rich bed of magnetite.
	SALEM— . . .	...	CHR. COR. G. GRT. LTE. MAG. SOP. TRP.	
	Godumalai (5) . . Kanjamalai (1) . Kolimalai (4) . . Singipatti (3) . .	Mem. IV, 280 . Ditto, 379-86. Ditto, 284. Ditto, 288.	...	The localities are numbered according to their importance, as groups.

MADRAS—*continued.*

IMPORTANT MINERALS—*continued.*

Mineral or Stone.	Locality.	Reference.	Other Minerals.	REMARKS.
IRON ORES, *I.—contd.*	SALEM—*contd.*			
	Tallamalai (4) . .	Mem. IV, 284	...	These five groups include all the important magnetite beds. The Porto Novo Iron Company had their smelting works at Pulampatti, 36 miles west of Salem, and used Kanjamalai ore. Native iron is largely made at Razapur, and Tammampatti. The Pulampatti iron was admirable in quality. The whole available stock in England was bought and utilized in the Britannia Tubular bridge. R. B. FOOTE.
	Tirtamalai (2) . .	Ditto, 289.		Salem is also famous for its chromic iron ore, for which see under Chrome ores. Not worked now.
	SOUTH ARCOT—			
	Chinna Tirupatti .	Man. III, 350 District Manual, 373 Mem IV, 293	...	Smelting on a large scale was formerly carried on at Porto Novo by the Iron Company of that name.
	Mudur Hill . .	Ditto, 294.		
	Pallapundi . .	Ditto, „		
	Pompurapi . .	Ditto, 292.		
	Virangani . .	Ditto, „		
	TANJORE . . .	...	CLY LTE Q SND.	No iron industry exists now, but the lateritic rocks along the western side of the district are locally quite rich enough in iron to have been worth smelting when fuel was cheap. R. B. FOOTE.

MADRAS—*continued.*

IMPORTANT MINERALS—*continued.*

Mineral or Stone.	Locality.	Reference.	Other Minerals.	REMARKS.
IRON ORES, *I.—concld.*	TINNEVELLY—	...	GRT. LIM. LTE. SAL SND.	
	The Southern Ghats	Rec. XVI, 24	...	Great quantities of Magnetic Iron sand are washed down from the mountains, but no iron industry exists now, nor have any traces of an older one been met with. R. B. FOOTE.
	TRAVANCORE STATE— Mukumnalli (Moocoomnalley)	Report, British Association, Oxford, 1860. 24.		
	TRICHINOPOLY	Man. III, 347.		
	Chattiramani Hill, Tholur	Mem. IV, 295	...	Two large and rich beds of magnetite.
GOLD, *G.*	BELLARY—	Man. III, 187	ANT. CLY. COP. COR. GRT I. MAG MAN. SND. SUP. TRP.	
	Camvehully	Balfour's Cyclopædia, 3rd Ed., 1885, Art. Gold.		
	Chiggateri	...	...	A tract of the Dharwar Series, west and north of Chiggateri, Harpanhalli taluk Fair shows of gold were obtained by washing in several places. Many good-looking reefs exist, but no free gold was seen in them. R. B. FOOTE.
	Jageraculliguda	Balfour's Cyclop.		
	Kongana	R. B. Foote.		
	MADURA	Man. III, 179; Balfour's Cyclopædia, Madura Manual, 30.		
	Veigei, R., Palakanuth	...	...	Poor auriferous sands; derived from the denudation of the Pulney Hills.

MADRAS—*continued.*

IMPORTANT MINERALS—*continued*

Mineral or Stone	Locality.	Reference.	Other Minerals.	REMARKS.
GOLD. *G—contd.*	MALABAR . . . Beypur R Karembat. Kupal. Nellambur Valley	Man III, 180, Balfour's Cyclopædia, Art Gold. Records, VIII, 30, 31; XI, 234—246		The Malabar low country in the Ernad Taluq has been famous for ages on account of its gold washings, though these have never been very rich The traditions of enormous gold production have no doubt arisen from the continued hoarding up, at certain periods in the old history, of gold from the generally small productions
	Wainád .	See under Nilgiri District	.	The Wainád country has within the last few years been redistributed what was called South East Wainad having been added to the Nilgiri district The gold-bearing reefs of South East Wainád extend into Malabar Wainád, where they also are to a lesser extent auriferous
	MYSORE AND COORG	Man III 185—187 Balfour's Manual		Mysore and Coorg are ordinarily considered a part of the Madras Presidency The auriferous tracts are therefore entered here incidentally. See under Native States.
	Belgumba . . Bellibetta . . Belligudda . . Chiknaiakanhalli . Chiranhalli . . Davangere . . Dharmapur . Girigudda, (Honnabetta) Gollarahalli . . Hallakalgudda Haltibetta (Hulmandibetta) Helgere . . . . Honnabetta (Girigudda) Honnahatti . .	Report on auriferous tracts in Mysore — R B Foote, 1887		

MADRAS—*continued.*

IMPORTANT MINERALS—*continued.*

Mineral or Stone.	Locality.	Reference.	Other Minerals.	REMARKS.
GOLD, *G.—contd.*	MYSORE AND COORG—*contd.*			
	Honnalli . . .	Rec. XV, 197.		
	Honnamaradi . .			
	Hulmandibetta (Haltibetta.)			
	Jalagaranhalli . .	Report on auriferous tracts.—R. B. Foote.		
	Kalinganahalli .			
	Karadihalli . .			
	Karimudanhalli .			
	Kempinkote . .			
	Kolar . . .	Rec. XV, 192–200.	...	The gold field *par excellence* of Mysore. It was opened up and carried on for some years in a very speculative and fitful way, until within the last four years when it has shewn its true value At present there are several companies at work; among them the Balaghat, Great South of Mysore, Kaisar-i Hind, Kolar, Madras, Mysore, Mysore Reefs, Nandidrug, Urigam, &c.
	Kotemaradi . .			
	Kudrikonda . .			
	Mallabannur . .			
	Mallanhalli . .			
	Nadapanhalli . .			
	Nuggin [illegible] . .	Report on auriferous tracts—R. B. Foote.		
	Pulvanhalli . .			
	Pura . . .			
	Shattihalli tract .			
	Sonnahalli . .			
	Sulladamaradi . .			
	Taggadurbetta . .			
	Yellavari . .			
	NILGIRI— . . .	Man III, 180, 134 Balfour's Cyclopædia, Art. Gold.	C Cly. Grt. Lte. Ld. Och. Trp. Znc.	A few quartz reefs, which have given indication of gold, are known on the Nilgiri plateau, but their exploitation has not been continued.
	Devalla (S. E. Wainád).	Rec. VIII, 20, 45; XI, 235. Report by R. Brough Smyth, 1880.	...	The gold industry in S. E. Wainád still keeps up a struggling existence. It promised fair in the early part of the eighties, and many Companies were started for working it; but so far this promise has not been fulfilled, very possibly

MADRAS—*continued.*

IMPORTANT MINERALS—*continued.*

Mineral or Stone.	Locality.	Reference.	Other Minerals	REMARKS.
GOLD, *G.—contd.*	NILGIRI—*contd.*			
	Devalla (S. E. Wainád)—*contd.*			owing to unsystematic and fitful working. There is no doubt of the auriferous character of some of the reefs, while the development of the reefs themselves is on an extraordinary scale. So far, it is not clear that this auriferous region has been thoroughly tested.
	Nunjanád . .	R. Brough Smyth, Rept. to Madras Govt., Nov. 1879		Quartz reefs, old mines and washing. Poor
	NIZAM'S DOMINIONS—Topuldodi . Wandali (Raichur Doab)	Rec. XXII, 235		A very promising tract, being exploited by the Hyderabad Deccan Company.
	SALEM— . . . Darampurai	Man. III, 170. Balfour's Cyclopædia.	CHR. CLY. COR. GRT. I. LIM. LTR. MAG. SOP. TRP.	Auriferous sands (magnetic iron sand) are known from the neighbourhood of Salem and Macdonald's choultry.
	TRAVANCORE— . .	Man. III, 178.	CLY. GAR. GRT. LTR. OCH. OIL. PLM.	
	Peermard . .	Rec. XV, 87, 88 .	...	In 1881, during the Wainád gold fever, hopes were raised in Peermard on the occurrence of quartz outcrops there. These outcrops are not of reefs, but merely of quartz-rock

MADRAS—*continued.*

IMPORTANT MINERALS—*continued.*

Mineral or Stone.	Locality.	Reference.	Other Minerals.	REMARKS.
GOLD, *G*—*contd*	TRAVANCORE—*contd.*			
	Peermard—*contd*			beds in the gneiss. A trace of gold was found in a small sample of the rock. There is however a certain amount of gold in the rocks of the country which is carried down into the low country, for a small amount of gold is occasionally washed for in the sands on the Quilon coast
PETROLEUM, *Oil*	MALABAR—		C CLY G GRI LTE OCH.	
	Calicut	Rec XXIII 40		Trace of oil The sea over the mud bank at this place appears to have a small quantity of oily matter distributed through it. In boring for the foundations of a bridge over the Kallai River, a layer of oily shale or mud was passed through.
	TRAVANCORE—Alleppy	Rec XVII, 14, 27	C CLY.	Trace of oil in the mud of smooth water banks
SALT, *Sal.*	CHINGLEPAT—Attiput, Cheyur, Covelong, Ennore, Káttur, Putivakum, Vadasamancheri, Vallur, Vayalur	Dist Man, 307		Salt pans. Very large out-turn.

MADRAS—*continued.*

IMPORTANT MINERALS—*concluded.*

Mineral or Stone.	Locality.	Reference.	Other Minerals.	Remarks.
SALT, *Sal.*—*contd.*	GANJAM— . .	Dist. Man., 274 .	GRT LIM STE	Salt-pans in Ganjam, Kalingapatam, Naupada, and Surla circles
	GODAVARI— . .			Salt-pans.
	KISTNA— . .	..		Salt-pans.
	MADURA— Attankarei . Mannikudi . Marakolum . . Muttaraghunapatam . Sholiakkuddi . Vattanum . . Vairavanáthapatanam	Dist. Man., Pt. 4, 40.	..	Salt-pans. Total out turn in Fasli 1275, 405 913 maunds.
	NELLORE— Binginapalli . Biramgunta . . Devarampad . . Dugarazapatam . Gogulapalli . . Iskapalli . . Kanuparti . . Krishnapatam . . Sunnapugunta . . Tada . . Tummalapenta . . Ullapalem .	Dist. Man., 599		Manufactured from sea water. Total out turn in the five years ending 1871, 593,873 maunds.
	SOUTH ARCOT— Chunámpett . . Gundalam . Kandádu . . Kudikádu . . Manamnbádi . . Mánavari . Markanum . .	Dist. Man., 460		Salt-pans. Total out-turn 1875 76, 346,276 maunds.
	TINNEVELLY . .	Dist. Man., 205 .	...	Eight factories, 1879.
	TRICHINOPOLY— Lalgudi (north of) .	Dist. Man., 68 .	...	Earth-salt, very impure, small village production.
	VIZAGAPATAM— Bálcheravu . . Bimlipatam . . Karasa . . Kupili . . . Pentakota . .	Dist. Man., 265	.	Salt-pans

MADRAS—*continued.*

MISCELLANEOUS MINERALS.

Alum, *Alm.* Antimony Ores, *Ant.* Arsenical Minerals, *Ars.* Asbestus, *Asb.* Bismuth and Cobalt Ores, *B.C.* Borax, *Bx.* Chrome Ores, *Chr.* Copper Ores, *Cop.* Corundum, *Cor.* Gypsum, *Gyp.* Lead Ores, *Ld.* Magnesia Minerals, *Mag.* Manganese Ores, *Man.* Mica, *Mi.* Natron *Nat.* Nitre, *Nit.* Ochres, *Och.* Phosphates, *Pho.* Platinum, *Plt.* Plumbago, *Plm.* Soapstone, *Sop.* Soda Salts, *Sod.* Sulphur, *Sul.* Tin Ores, *Tn.* Zinc Ores, *Znc.*

Mineral or Stone.	Locality.	Reference.	Other Minerals.	REMARKS.
ANTIMONY ORES, *Ant.*	BELLARY— Sundur Hills .	Man. III, 164. Bellary District Manual, 95.	G. I. LD. MAN	No traces found in the progress of the Geological Survey.
	VIZAGAPATAM— .	Man. III, 164. Vizagapatam District Manual, 155 Balfour's Cyclopædia.	I. MAN. GAR. GRT. LTE.	
ASBESTUS, *Asb.*	SALEM— . . .	Man. III, 519 .	...	No true asbestus is known. The fibrous form of Serpentine (Baltimorite) is commonly associated with the Magnesite veins at the so-called "Chalk Hills" north of Salem town.
CHROME ORES, *Chr.*	SALEM— Karupur . . .	Man III, 333; Mem. IV, 315.	MAG. .	Chromic Iron, old mines in the neighbourhood of the "Chalk Hills," long abandoned.
	TRICHINOPOLY— Yedichicolum . .	Jour., Roy. As. Soc VII, 169.	CLY. GRT. GYP. LIM. LTE. MI. NIT. OCH. Q. SND. TRP.	On the banks of the Cauvery River.
COPPER ORES, *Cop.*	BELLARY— Harpanahali . .	R. B. Foote .	...	Two old workings of small size, north-east by north of the town. Green carbonate lining cracks in a run of brecciated quartz rock.
	Sugamma Betta (Copper Mountain).	Newbold, Journ. Roy. As. Soc. VII, 150.		

MADRAS—*continued.*

MISCELLANEOUS MINERALS—*continued.*

Mineral or Stone	Locality	Reference	Other Minerals.	REMARKS.
COPPER ORES, *Cop.—contd.*	CUDDAPAH—	...	D LD. LIM. LTE. OCH. SND. SLT. TRP.	
	Jungumtazpali	Man. III, 240; Mem VIII, 270, Jour Roy As. Soc. VII, 150.	.	Old lead mines, long abandoned Considerable mining appears to have been carried on here when the country was under Muhamadan rule. Only traces of copper ore.
	KISTNA—	..	D. GAR. GRT. LD. LIM. LTE PLM. SLT. SND.	
	Agnikonda (Agnigundala)	Man III, 241 Mem VIII, 269; Heyne's Tracts, 108	..	Extensive old workings Green and blue carbonates of copper in pockets, Mine worked out R. B. FOOTE.
	KURNOOL—	...	D. GRT LD LIM LTE SLT SND SOP TRP	
	Gani Hill	District Manual, 96	...	Vandutla, or Undutla plateau; old mines.
	Gumankonda	Man III, 240 Mem. VIII, 268	.	Old and worked-out mine.
	Remata	...	...	Films of earthy green carbonate lining joints in a run of brecciated quartz rock. R. B. FOOTE
	Somadulpilli	Man. III 241 Mem VIII, 269		
	NELLORE—	..	CLY GYP. GRT. LTE. MI. SAL. SND. TRP.	
	Garimanpenta or Gunnipenta Gorganpili. Yarapilli.	Man. III, 242; Mem. XVI, 185; Rec. XII, 171, Heyne's Tracts, 108; Journ. As Soc, Bengal IV, 575; Journ. R. As. Soc. VII, 150, Dist. Man. 60—63.	..	Many attempts have been made to work the Nellore copper ores: but all have fallen through. The traces of copper ore are, however, very numerous, and occasionally promising.

MADRAS—*continued.*

MISCELLANEOUS MINERALS—*continued.*

Mineral or Stone.	Locality.	Reference.	Other Minerals.	REMARKS.
COPPER ORES, *Cop.—contd.*	TRICHINOPOLY— Olapadi . . . Vepur.	Man. III, 240; Mem. IV, 216, Dist. Man, 69.	...	Traces.
CORUNDUM, *Cor.*	ANANTPUR— Madaksira . . Punighi . . .	Man. III, 423.	...	Sea green colour. Local price R5 to 7 per 100 seers by measure.
	COIMBATORE—	...	BRL. GRT. LIM. Q.	
	Chennimalai . . Gopichettipaliam. Gajelhatti.	Man. III, 422, Journ. R. As Soc VII, 224, Dist. Man, 23.		
	Patalai . . .	..	.	Corundum of fine quality, largely exported.
	KISTNA— Guntur . . .	Man. III. 424. Sel. from Rec. Govt. of Madras No. XXXIX, 90.		
	MYSORE— Appianhully . . Arumali . . . Bagipali . . . Beygur . . . Burkunhully . . Deysani Kurbanhalli Golushully . . Kuddur . . . Kulkairi . . . Kundio . . . Mundium . . Norhik . . . Nullapardi . . Perniuti . . . Yedgunkul . .	Man. III, 422; Madras Jour Lit. and Sci. XI, 46 · Journ. R. As. Soc. VII, 219; Mysore Gazetteer.	..	Localities and references are only given here incidentally; Mysore being ordinarily considered as in the Madras Presidency.
	NORTH ARCOT— Naggari Hills . .	Man. III, 423; Sel. from Rec. Govt. of Madras, No. XXXIX, 92.		
	SALEM— Nammal . . .	Man III, 422, Cal. Jour. Nat. Hist. I, 281.		

MADRAS—*continued.*

MISCELLANEOUS MINERALS—*continued*

Mineral or Stone	Locality.	Reference.	Other Minerals.	REMARKS.
CORUNDUM *Cor.—contd.*	SALEM—*contd.* Shoslasirgamani .		...	Very abundant at Sholasingamani. Rubies are reported to have been found at Viralimodos and Sholasingamani R. B. FOOTE.
	Viralimodos .	Man III, 422, Cal Jour Nat Hist II 281	.	
GYPSUM, *Gyp.*	CHINGLEPUT— Estuarine beds north of Madras.	Mem X, 132	.	Occurs as crystals of Selenite.
	NELLORE— Northern part of the coast canal	Mem XVI 104		Selenite crystals in the marine clayey beds of finer quality and better color than those of Madras.
	TRICHINOPOLY— Maravatur, north-east of	Mem IV, 214	Lim .	Common among the clays, from which it is difficult to obtain it clean.
	Utatur east of.	.		
LEAD ORES, *Ld*	BELLARY— Sundur Hills .	. Dist. Man 95 .	.	No authority is quoted for this statement and no traces of lead were met with during the survey of the state R. B FOOTE
	CUDDAPAH .	. Man. III, 281 85 Jour R As Soc VII, 217 Madras Jour Lit. & Sci XX, 279 & 289, Dist Man, 26, Heyne's Tracts 316		
	Jungumrazpilli or Buswapur	Mem VIII, 293 .	Cop	A region of old and extensive mines long deserted.
	Kotalur .	Madras Jour. Lit and Sci. XX, 280	...	Crystals of galena in a quartz lode crossing the Penner R.

MADRAS—*continued*

MISCELLANEOUS MINERALS—*continued*

Mineral or Stone	Locality	Reference	Other Minerals	REMARKS.
LEAD ORES *Ld.—contd.*	CUDDAPAH—*contd.* Kundalu Bori . .	Jour. R. As. Soc. VII, 217.		
	Nagsanpali . Poleram Manu .	Madras Jour. Lit. and Sci. XX, 279, 289	.	The main lode at Nagsanpali extends into the Lunkamalla Hills.
	KISTNA— Karampudi (Palnad)	Man. III, 285 Mem. VIII, 270	D. Lst. Slr. Sst.	A locality of old lead mining, among pale grey and whitish siliceous limestone.
	KURNOOL— Gazulpully (also referred to as Buswapur).	Man. III, 274 Mem. VIII, 273 Jour. As. Soc. Beng. XV, 52, 350, XVI, 1132 Madras Jour. Lit. and Sci. XX, N. S., 280	Cop. Lim. Sil. Ssp.	Old mines. Argentiferous.
	Kotkuntla .	Madras Jour. Lit. and Sci. XX, 290		Argentiferous.
	SALEM— Mallur Railway Stn. (East of)	Mem. IV, 237		A large quartz lode in the gneiss crossing the road to Harur, 3 miles from the station proved on being dug by prospected in 1882 to contain nests of galena. R. B. FOOTE.
MAGNESIA MINERALS *Mag.*	BELLARY— Daroji . . .			Small veins of white magnesite in the schist beds of the ridge south of the Daroji tank bund or embankment. R. B. FOOTE.
	SALEM— The 'Chalk Hills' .	Man. III, 438 Mem. IV, 312 Jour. R. As. Soc. VII, 101, Dist. Man., 104		A tract some ten square miles in area traversed by innumerable veins of magnesite.
	Kajupatti			
	Pavitram . .	.	..	S. E. of Namakal.

MADRAS—*continued.*

MISCELLANEOUS MINERALS—*continued.*

Mineral or Stone.	Locality.	Reference.	Other Minerals.	REMARKS.
MAGNESIA MINERALS, *Mag.—contd.*	TRICHINOPOLY— Tripangulı (10 miles N. W. by W. of Trichinopoly) .	Mem. IV, 321 .	...	Magnesite strings in travertine or calcareous tufa, apparently due to the action of old thermal springs.
	Valikondipuram .	Ditto, 323 .		
MANGANESE ORES, *Man.*	BELLARY— Ramandrug. Ditto, Western slopes.	Rec. XXII, 26 .	.	Nodules of Haussmanite in schists. R. B. FOOTE
	Sundur Hills . .	Notes on Econ. Geol of the Sundur State, Madras Govt. 1889, p. 4.	.	South-west spurs, a large supply easily obtainable by quarrying.
	Ditto, ditto . .	...	.	On the southern flank of the Sundur hills; concretionary manganese ore in hæmatite schists and quartzites. R. B. FOOTE.
	KURNOOL . . . Banaganpilli Korlkantta Nandavaram	Dist. Man., 69 .		Said to occur.
	NILGIRI — . .	Dist. Man., 83 .	C CLY G. GRT LTE OCH	
	Coonoor . . . Kaiti Valley . . Ootacamund Lake .	Madras Jour. Lit. and Sci. XXII, 253.	.	No evidence as to abundance or variety. R. B. FOOTE
	VIZAGAPATAM— Bimlipatam . .	Man III, 327; Rec. XIX, 155, Edin. New Phil. Jour. LIII, 277.	GRT. LTE. .	Occurs in small quantity on the lateritised top of the hill.
	Ramachandrapuram (Salur).			
	Vizianagram . .	...	LIM. .	Six miles north of Vizianagram on the road to Palkonda. Psilomelane, associated with limestone.

MADRAS—*continued.*

MISCELLANEOUS MINERALS—*continued.*

Mineral or Stone	Locality.	Reference.	Other Minerals.	REMARKS.
MICA, *Mi.* (Erroneously called Talc: Mica is an elastic mineral; Talc is only flexible and seldom in plates.)	VIZAGAPATAM—Kodur . . .	Man III, 525, Dist Man, 155	...	Said to be obtainable in any quantity but it cannot be of good quality, as it sells at the rate of 24lb for the rupee. NOTE—Mica is one of the most commonly distributed minerals: though it seldom occurs in large enough plates to be of commercial value. Most of the mica used for small pictures and ornamental work, as at Trichinopoly, is imported: but for minute work and spangles good enough material can be obtained in most of the districts as Bellary, Coimbatore, Salem, Trichinopoly, &c.
NITRE, *Nit.*	MADURA . . .	Man. III, 499, Dist Man, 25.	...	A common product of efflorescence from poor soil in the neighbourhood of old villages, used to be largely manufactured.
	NELLORE—Atmakur Taluk . Gudur „ . Itamukula . . Kavali Taluk . Kundukur „ . Nellore „ . Mahimalur . . Rapur Taluk . . Vassili . . . Virur . . .	Dist. Man., 67 .	...	Very superior saltpetre has been exhibited from Mukula.
	SALEM . . .	...	..	Large quantities of nitre were produced in this district until within late years. R. B. FOOTE.
	TRICHINOPOLY . .	Mem. IV, 374, Dist Man, 248.	...	Earth salts are very common as efflorescences, particularly in the areas of crystalline rocks. It was ascertained by commission in 1876, that 13,719 maunds of salt petre were manufactured yearly.

MADRAS—*continued.*

MISCELLANEOUS MINERALS—*continued.*

Mineral or Stone.	Locality.	Reference.	Other Minerals.	REMARKS.
OCHRES, *Ochr.*	BELLARY— Baltada Mulla.			
	Copper Mountain	...	I.	Rich red ochre.
	Kalhalli Hills	...	...	Red, brown, yellow, and purple ochres in great variety of tints, large in quantity and of excellent quality, occur in the ferruginous schist bands of these regions. R. B. FOOTE.
	Komaraswami.			
	Ramandrug.			
	Sundur Hills	Notes on Econ. Geol. of the Sundur State, Govt. of Madras.		
	NILGIRI— Nilgiri Plateau Ootacamand.	Man. III, 417, Mem. I, 237: IV, 214	CLY. G. GRT. LIF	Ochreous minerals are exposed in many cuttings and excavations in the decomposed country rock, gneiss.
	TRICHINOPOLY— Trivandpuram	Man III, 417	...	Yellow ochre. NOTE. Red and yellow ochres of many hues are of very common occurrence in all the laterite tracts of S. India. R. B. FOOTE.
PLUMBAGO, *Plm.*	GODAVARI— Beddadanol (Coal field).	Man III, 53	C. SND	In sands of river, washed down from crystalline area. Only traces. Poor graphite is also obtained at many places in the hilly country bordering the western edge of district.
	KISTNA— Bezwada	Man III 53, Rec VII, 100.	..	Poor and sparingly distributed.
	MADURA— Pantalagudi	Mem. XX, 21	..	Traces in crystalline limestone.
	TINNEVELLY— Ambasamudrum Cudacurchi	Man. III, 53	...	Doubtful, but not improbable. Said to be from decomposing gneiss and also in kunkar.

MADRAS—*continued*

MISCELLANEOUS MINERALS—*continued.*

Mineral or Stone	Locality.	Reference.	Other Minerals.	REMARKS
PLUMBAGO *Plm.—contd.*	TRAVANCORE—			
	Ponmilal (10 miles N. E. of Trivandrum)	Man. III, 51, Journ As Soc Beng XIV lxiv XXIV, 213 Madras Jour Lit and Sci 1856, p 257		In veins in the gneiss.
	Vellurnad (near Arinad)	Ind in Mus	.	About the best form of graphite known in the Madras Presidency. Fairly large quantity
	VIZAGAPATAM—			
	Kasipuram . .	Man III 53 Dist Man. 154		
	Rampilli (Salur) .	Rec XIX, 155 .		Poor, and very much mixed with gneissic material
SOAP-STONE, *Sop.* (Includes Steatite Pot stone Talc (not Mica), Bulpum)	ANANTAPUR—			
	Gulumarri . .	Rec XXII 62		A serviceable form of steatite compact and free from grit
	Narjampaki			
	BELLARY—			Considerable industries in soapstone vessels W of Nagaras andevergudda, and at Somulapur Old quarries at Angur and Nilgunda The beautifully carved old temples on Nilgunda tank-bund at Hira Kuravatti (on the Tungabudra R) and at Hira Haddigal are built of hard steatite R B FOOTE.
	Angur (Haddagalli Taluk)			
	Arsapur hill (Harapanahalli T.)			
	Harapanahalli N of Hossahalli, S E of.			
	Huchangi Drug E of (Harapanahalli T)			
	Kanchkerra (Harapanahalli T.).			
	Karasundevergudda, W. of. (Harapanahalli T)			
	Nilgunda (Harapanahalli T)			
	Somalapur (Kudligi T)	Rec. XXII 62		
	COIMBATORE—			
	Dodarapâlaiam	Dist. Man, 23.		
	Edamaranahalli (Kollegal Taluk).	Rec XXII, 63 .	...	Gritty in cutting.

MADRAS—continued.

MISCELLANEOUS MINERALS—continued.

Mineral or Stone.	Locality.	Reference.	Other Minerals.	REMARKS.
SOAP-STONE, *Sop* —*contd.*	KURNOOL— Maddawarum (Nandial Taluk)	Mem. VIII, 166; Rec. XXII, 61, Dist. Man., 97.	Lim. Snd. Trp.	Four miles east of Betamcherla Station, Bellary-Kistna Ry. The best variety out of several samples sent from all India for trial as suitable for gas-burners in London. Estimated cost per ton delivered in London, £3-7 to £4.
	Penda Kallu (Ramalkota Taluk)	Rec. XXII, 62		Seams, free from grit, soft and easily cut.
	NORTH ARCOT— Pathur (Chittur Taluk)	Rec XXII 63	...	Rather hard to cut, but free from grit.
	SALEM— Eswaramalai Hills (Atur Taluq)	Rec XXII, 63	...	Gritty, cuts with difficulty.
	Karupur (7 miles N W of Salem) Tandagaundenpolliam (17 miles E S E of Salem) Yarmapatti (35 miles S by E of Salem)	Mem IV, 317, 324	...	A large industry in pot-stone vessels was carried on at each of these villages at the time of the survey R. B. FOOTE.
	SOUTH KANARA— Manavalike . . Nerankimagave (Uppinangadi Taluk).	Rec. XXII, 63	...	Cuts very freely. Quarry or quarries 600 square yards. Cost of delivery at Madras, R20-2 per ton
SODA SALTS, *Sod.*	SALEM— Baramahal . .	Trans. Bomb. Geol. Soc., VI, Jour. As. Soc., Beng X, p 159.	...	Soda salts occur in every district, and especially in dry beds of streams that drain cotton soil areas.
SULPHUR *Sul.*	GODAVARI DIST — Sura-Sani Yanam (on the coast in the Delta).	Heyne's Tracts, p 186.		

MADRAS—*continued.*

MISCELLANEOUS MINERALS—*concluded.*

Mineral or Stone.	Locality.	Reference.	Other Minerals.	REMARKS.
ZINC ORES, *Znc.*	KURNOOL DIST.—Baswapur[9] . .	Rec XIV, 196 and 305.	...	Smithsonite and Blende. Specimens of unknown origin sent to the Vienna Exhibition collection from Kurnool in 1873 Supposed to come from Baswapur.

GEM-STONES.

Amber, *Amb.* Beryl, *Brl* Diamond, *D* Garnet, *Gar.* Jade, and Jadeite, *Jd.* Quartz, *Q.* Rubellite. *Rbl.* Ruby, *R* Sapphire, *S.* Spinel, *Spl.*

Mineral or Stone.	Locality	Reference.	Other Minerals	REMARKS.
AMBER, *Amb.*	TRAVANCORE STATE .	Ainslie, Materia Medica 3 Balfour's Cyclopædia Art Amber	...	Copal.
BERYL, *Brl*	COIMBATORE— . . Padiur . . .	Dist Man, 23 P Bosworth Smith, 1888		
	Pattalai (or Kangyam).	Edin Phil Jour XXXIX 171 Madras Jour Lit and Sci XII 173 Walhouse "Indian Antiquary" Vol IV, Dist. Man, 23. Man. III 520.	GAR GRT. Q	Occurs in prophyritic dyke. Aquamarine. Beryls are reported to have been found at Vaniambadi at northern base of the Nilgiris and at the foot of Lambton's Peak.
DIAMOND, *D.*	ANANTAPUR—Wajra Karur (10 miles S. of Guntakal Junction Ry. Stn).	Man III, 12 Rec XIX 100, XXI. 39, XXIII, 09	GRT .	The diamonds which have given the place its reputation were all found on the surface close to the village or in its environs. Their source is still an enigma. R. B. FOOTE.

MADRAS—*continued.*

GEM-STONES—*continued.*

Mineral or Stone.	Locality.	Reference.	Other Minerals.	REMARKS.
DIAMOND, *D.—contd.*	BANAGANPILLI STATE—(*Kurnool District*)—			
	Banaganpilli .	Man III, 13; Mem VIII, 106.	LIM., SND.	The low hills west of the town are mined for diamonds which occur in pebbly and gravelly clayey seams among the thicker beds of quartzite sandstone forming the surface of the hill. A very languid industry still exists, which, however, consists chiefly of turning over the old waste heaps in search of small diamonds which may have been missed in the previous search.
	CUDDAPAH— . .	...	LD. LIM. SLT. SND.	
	Chennur . . Kunnapurti . . Woblapali . .	Man. III 9-24, Mem. VIII 266 Dist. Man., 24.	...	Diamond workings in alluvial deposits of the Penner R The industry has been long dormant. There is no reason for concluding that the area of diamondiferous alluvium has been worked out.
	GODAVARI—			
	Badrachellum . .	Mentioned by Voysey and Newbold.	...	Unlikely: but strata of the Cuddapah and Kurnool formations occur within the drainage area.
	KISTNA . . .	Man. III, 16; Dist. Man.		
	Golapalli . .	See below, under Maleli.		

MADRAS—*continued.*

GEM-STONES—*continued.*

Mineral or Stone.	Locality.	Reference.	Other Minerals.	REMARKS.
DIAMOND, *D.—contd.*	KISTNA—*contd.* Kollur (Gani Conlur)	Man. III, 16 .	...	Alluvial Deserted. Great part of the wild forest tract between the Kollur and Chintapilli reaches of the Kistna R. is full of old abandoned diamond mines. R. B. FOOTE
	Kodavettikallu	Man. III 22	...	Alluvial.
	Maleli (or Malavili) .	Mem. XVI, 253 Rec V 27 Heyne's Tracts.	.	Partly mined and partly alluvial. Long deserted.
	Mullawarum . .	Mem. VIII 110 .	.	Mines . All deserted although the alluvial ones may be occasionally worked.
	Munnalur . .	Man. III 22 .		Alluvial
	Sarangapali hill . .	Mem. VIII 100 .	...	Old mines.
	Ustapalli . .	Man III 22 .	...	Alluvial
	KURNOOL . . .	Man III 13, Mem. VIII 96, Dist Man., 94.	Cly Cop Ld Lim Ltr Slt Snd Sop. Trp.	
	Bannur (*a*) . .	.		Rock workings Abandoned ?
	Buswapur (*b*) . .	.		Rock and alluvial workings long deserted.
	Byanpalli (*b*) . .	...		Rock working now.
	Deomarru . .	...		Rock working; abandoned.
	Devanur (*a*) . .	..	Snd. Cly.	Rock working; ? abandoned.
	Gudipad (*a*) (Nandikotkur Taluk).	...		Rock working; abandoned.
	Guramankonda (*b*).			
	Kappatralla (*e*) (Pattikonda Taluk).	..		Old rock workings, abandoned, outlier west of Kurnool. R. B. FOOTE.

MADRAS—*continued.*

GEM-STONES—*continued.*

Mineral or Stone.	Locality.	Reference.	Other Minerals.	REMARKS.
DIAMOND, *D.—concld.*	KURNOOL—*contd.* Munimadagu	...	SND, CLY	Once an important centre of mining and polishing; long abandoned.
	Pulikonda hill (*e*) (Pattikonda Taluk).	...		Old rock workings, abandoned; outlier west of Kurnool R. B. FOOTE.
	Ramullakotta (*c*)	Mem. VIII. 105		Rock workings, abandoned, alluvial digging and washing still goes on. Answers to the Raolconda of Tavernier.
	Saitankota (*d*)	Ditto, ditto		Abandoned rock workings.
	Tandrapad (*d*)	...		Alluvial, abandoned.
	Timmapuram (*c*)	...		Rock workings still in progress.
	Venkatapur hill (*e*) (Pattikonda Taluk)	...		Old rock workings, abandoned R. B. FOOTE.
	Yembai (*b*) (Nandial Taluk).			
	The above localities are grouped under (*a*), (*b*), (*c*), (*d*), (*e*).			
	NIZAM'S DOMINIONS—Atkur or Atanur, Barthenypadu, Mugalur, Partial	Man. III, 22	...	Alluvial diggings and workings. Are being now exploited by the Hyderabad Deccan Company with very questionable success. Referred to here incidentally, as being generally considered in the Madras Presidency. See under Native States.

MADRAS—*continued.*

GEM-STONES—*continued*

Mineral or Stone.	Locality.	Reference.	Other Minerals.	REMARKS.
GARNET, *Gar.*	GODAVARI— Kondapilli .	Man. III, 521, Mem. XVI, 204	Grt . .	Kondapilli has long been famous for its garnets and carbuncles (polished form), though the industry is very feeble. The garnets are washed down from the garnetiferous gneiss of the adjacent hills.
	NELLORE— Chundi hills . .	Mem. XVI 15 164.	.	The prismatic form of garnet, called *Staurolite*, occurs with *Kyanite* in micaceous schists These crystals of staurolite which are very common in the schists of the Chundi hills, would make a better substitute for emery than the garnet sand so largely collected for this purpose. Garnet sand is collected similarly in many other districts of the Presidency R. B. FOOTE.
	Picherla Konda.			
	Saidapuram } Tummulatalapuru }	Mem. XVI, 135		Remarkable specimens of large size and very perfect crystallization Of no value as gem-stones.
	NILGIRI— .	..	C Cry G, Grt Lm, Lte Ochr, Znc.	
	Seven Cairns hills	Man. III 523, Jour. R As. Soc. VII, 224.	...	Cinnamon stone or *Hessonite.*
	SALEM— Kanjumalai . .	Mem. IV, 380	...	Good in colour, but very difficult of extraction.
	Sankagiri Drug .	Jour. R. As. Soc. VII, 224.	...	Green garnets were found here by Captain Newbold.

MADRAS—*continued.*

GEM-STONES—*continued.*

Mineral or Stone.	Locality.	Reference.	Other Minerals.	REMARKS.
GARNET, *Gar.—contd.*	TRICHINOPOLY— Kalpatti . . .	Mem. IV, 275 .	LIM. . .	Massive garnet, *Calderite*, in crystalline limestone.
	VIZAGAPATAM— .	...	...	The gneisses of the Vizagapatam District, are essentially garnetiferous.
	Borrakonda hills .	Man. III, 522; Dist. Man., 155.	...	The garnets brought in from the Borrakonda hills near Galikonda, are probably only of value as polishing material, used instead of emery.
QUARTZ, &c., *Q.* (Includes rock crystal and the various forms of Quartz: as Agate, Amethyst, Bloodstone, Chalcedony, Chert, Flint Jasper, Onyx, Opal, &c.)	COIMBATORE— Dharapuram . . Kangyam.	Dist Man, 23 .	...	Rock crystal; Amethyst.
	CUDDAPAH— Boodanampally . Chitravutti gorge .	Manual III, 502, Mem. VIII, 153	..	Ribbon jaspers very common as pebbles in the quartzite sandstone conglomerates.
	GODAVARI— Godavari R. . .	...	.	Pebbles of rock crystal, chalcedony, chert, onyx, &c., are common in the river gravels at various places along its course.
	KISTNA— Kistna R. . .	...	...	Ditto ditto.
	KURNOOL— Dhone . . . Kistna R. Yeldurti	...	...	Ribbon jaspers common in the conglomerate east of Dhone, Kurnool itself, Yeldurti; and in the Kistna R. gravels, which contain also pebbles of rock-crystal, chalcedony, chert, onyx, &c
	NZIAM'S DOMINIONS— Ramgirpet . .	...	..	A large vein of amethystine quartz. Road metalled with it, between Bhonagir and Pembarti.

MADRAS—*continued.*

GEM-STONES—*concluded.*

Mineral or Stone.	Locality.	Reference.	Other Minerals.	REMARKS.
QUARTZ, &c., Q—*contd.*	TANJORE— Vallum . . .	Man. III, 502, Mem. IV, 217, 370.	LTE . .	Noted as being a place where pubbles of rock crystal are collected, probably from the debris of the conglomerates in the neighbourhood. The amethysts said to be from here, were probably imported from the Coimbatore District.
	TRICHINOPOLY— Kurichikulam . . (Udarpalaim Taluk) Sainthoray . .	Mem. IV, 213, Dist. Man. 67	..	Flint stones from the cretaceous rocks. NOTE—Quartz being one of the commonest rock minerals, its presence in one form or other, particularly in the crystalline condition, is almost universal.
RUBY, *R.*	SALEM— Sholasigamani . . Viralimodos.	Man. III, 429, Jour. R. As. Soc. VII, 224.	COR . .	Probably a red coloured variety of crystallized corundum and as such a form of poor ruby.

QUARRY STONES.

Clays, *Cly.* Granite, Gneiss, &c., *Grt.* Laterite, *Lt.* Limestone, Marbles, Kunkar, &c., *Lm.* Slate, *Slt.* Trap, Basalt, &c., *Trp.*

Mineral or Stone.	Locality.	Reference.	Other Minerals.	REMARKS
CLAYS, *Cly.*	CHINGLEPUT— Kuppam . . Pakkam Nala . . Sripermatur . . Valley of the Attram	Man. III, 561, 509, Mem. X; 134.	...	Extensive beds of high class white or pale clays occur in the Upper Gondwana (Rajmehal) series. The Kuppam clays yielded good results at the Madras School of Arts. R. B. FOOTE.

MADRAS—*continued.*

QUARRY STONES—continued.

Mineral or Stone	Locality	Reference.	Other Minerals	REMARKS.
CLAYS, *Cly.* —*contd*	KISTNA— Chebrolu .	Mem. XVI, 80 .	...	Fine white clays occur among the patches of the Upper Gondwana series, about Chebrolu, in the neighbourhood of Guntur
	MALABAR— Calicut Tirivaloy (Palghat) .	Dist Man .		Brick and tile factories at Calicut and Tirivaloy clays being obtained from river beds of neighbourhood.
	NELLORE Pyndipadu Vemavaram .	Mem XVI, 62, 67.	.	Soft clays and shales in beds of Upper Gondwana series
	NILGIRI . .	Dist Man 91		Kaolin
	NORTH ARCOT— Guddiathanur Vellore . .	Rec XII 207		Supply of Kaolin
	SOUTH ARCOT— Panarutti .	Man III, 562 .		Fine plastic clay near the south bank of the Gud-dalum R
	SOUTH KANARA— Mangalore, N of	Jour As Soc Beng X, 907	Lte. .	Clay of very fine character A large brick and tile factory carried on by the Basel Mission
	TRAVANCORE STATE .	Industrial Arts of Ind 2, 135		Manufactured into red earthen-ware.
	TRICHINOPOLY— Teraiu . Utakoil .	Mem IV, 211 . Ditto, 212		Pottery clay. Pipe clay of fine quality Common red clays.
	Vemmani . .			Plastic clay
	VIZAGAPATAM— .		Cor Gar Grt Lim Lte Man Mi Nit Ochr Plm Sal	
	Vizianagram . .	Rec XIX, 153 .		Kaolin of superior quality, approved at the Madras School of Arts

MADRAS—*continued.*

QUARRY STONES—*continued.*

Mineral or Stone.	Locality.	Reference.	Other Minerals.	REMARKS.
GRANITE, &c., *Grt.* (Includes all fairly compact crystalline rocks; as gneisses of all kinds, generally of grey-greenish, or flesh colors. Not compact, massive, black or dark-green rocks such as Basalt Trap, &c.)	ANANTAPUR— Anantapur Garladinni Guti Nagasamudra hills Patakacheruvu hills Sankarabauda Uruvakonda hills	...	...	Great wealth of fine granites and gneisses of many tints in the Anantapur and Guti taluks. R. B. FOOTE.
	BELLARY— Adoni Alur Bellary Darosi Gudikotai hills Hampi Harapanahalli Jerrimalla hills Kotakal hill Kurgode Raidrug hills Sauganka Takkalkota	Dist. Man., 93	...	The Bellary district is immensely rich in granites and gneisses. First class stone can be obtained at all the places named, and at many others also. At Hampi, there are many remarkable ruins, shewing fine carvings in local granite and several noble monoliths of great size. R. B. FOOTE.
	CHINGLEPUT—	...	Cly. Gyp. Lte. Ochr. Sal. Snd.	
	Cuddaparai Choultry Nandiveram Palaveram Patandalam Seven Pagodas Tirukari Kundram Wallajabad (2½ miles N. E. of.)	Mem. X, 131	...	At Palaveram Cuddaparai and Patanpalam, highly hornblendic gneisses very largely quarried for articles of domestic use. Palaveram yields the rubble stone used in the Madras Harbour Works. At Nandivarum, beautiful pale, yellow and pinkish granitoid admirably adapted

MADRAS—*continued.*

QUARRY STONES—*continued.*

Mineral or Stone.	Locality.	Reference.	Other Minerals.	REMARKS.
GRANITE, &c., *Grt.—contd.*	CHINGLEPUT—*contd.* Cuddaparai Choultry, &c.—*contd.*			for ornamental purposes, but not used as yet. Very fine and large blocks, 14 to 16 feet long, of hornblendic gneiss at Wallajabad. At Tirukari and Seven Pagodas, granite largely quarried. R. B. FOOTE.
	COIMBATORE— Karur . . . Palghat (North side of gap) . . .	Dist. Man. 20, Mem. IV, 147.	...	Schistose forms of gneiss predominate generally; but massive granitoid bands at the places mentioned. R. B. FOOTE
	GANJAM— Mahendragiri . .	Man. III, 536.		
	KISTNA— Ballamkonda . .	Mem. XVI, 107	GAR. .	Three extensive old hill forts built of the rock they stand on. Much of the granite is very handsome in color and texture, and susceptible of very high polish. The rock of Kondavidu is especially noteworthy for its great variety and beauty of color. R. B. FOOTE.
	Kondapilli hills.			
	Kondavidu hill .	Ditto, 106		
	Vinukonda . .	...		
	MADURA— Ambalathandi.			
	Ansimallai.			
	Arupukotai . .	Mem. XX, 100 .	...	A splendid rich, red stone; quarries very well and of great size.
	Kalligudi Chuttram .	.	...	Pale granitoid, with many pink garnets, largely quarried.
	Kotaipardi . .	...	...	Rich red stone.
	Numurupur.			

MADRAS—*continued.*

QUARRY STONES—*continued.*

Mineral or Stone.	Locality.	Reference.	Other Minerals.	REMARKS.
GRANITE, &c., *Grt.—contd.*	MADURA—*contd.* Puliarpatti . .	Rec. XII, 146, 157	...	Pale banded hornblendic rock, largely quarried for temple pillars, &c.
	Shayalpatti.			
	Tirnparaikundram.			
	Tirushulai . .	Mem. XX, 99.		
	NILGIRI— Dodabetta (N. side of).	Mem. I, 245, Dist Man. 83, 97.	...	Hornblendic gneisses, well suited for quarrying.
	Ell Hill (S. side of) .			
	Kaiti valley . .			
	NORTH ARCOT— Chetput . . .	Rec. XII, 207 .	..	Very handsome and useful granites, and massive gneisses are quarried, often on a large scale, at the places mentioned. Sholingar stone is largely used in Madras, a very handsome dark-green and pink syenitoid can be got on the western slope of the Nagari Nose mountain.
	Nagari hill . .			
	Palikonda . .			
	Ranipett . . .			
	Sholingar . .			
	Trittani . . .			
	Vellore . . .			
	Wandiwash . .			
	PUDAKOTAI STATE— Kunamulla . .	Rec. XII, 146, 157	...	Very handsome rock of pale shades of bluish and whitish-grey.
	Tirukundam.			
	Tirumayam.			
	Virallimallai, (20 miles S. W. of Trichinopoly.)	...	.	A very beautiful stone; pink, banded with grey or black, in vandyke patterns. R. B. FOOTE.
	SALEM— Sankeghiri Drug .	Mem. I, 228 .	...	Many large veins of true eruptive granite occur here, cutting through the gneiss.

MADRAS—*continued.*

QUARRY STONES—*continued.*

Mineral or Stone.	Locality.	Reference.	Other Minerals.	REMARKS.
GRANITE, &c, *Grt.—concld.*	SALEM—*contd.* Yailagiri . . .	...	..	Very handsome porphyritic granite occurs largely on the western flank of Yailagiri. R. B. FOOTE.
	SOUTH ARCOT— Gangaveram hills . Gingee . . . Tiagar Drug . .	Mem. X, 77 .	...	Handsome granitoids susceptible of high polish.
	TINNEVELLY— Kolapatti . . Waddakarai . .	Mem. XX, 23, 101	GAR. .	Pale granitoids. with many small pink garnets. Largely quarried at Waddakarai. Many very fine granitoids exist to the south of Palamkotta, but no great quarries were met with during the survey.
	TRAVANCORE STATE— Cape Comorin . .	Rec. XV, 89; XVI 24.	...	Gneisses, generally like those of the Nilgiris, but more quartzose. The Cape Comorin type of rock which abounds in S. Travancore is a well-bedded, massive quartzo-felspathic granite-gneiss; abounding in small rich-coloured garnets.
	TRICHINOPOLY— Golden rock . .	Mem. IV, 367.		
	Mammalai . .	Ditto, 1.		
	Perambalur . .	Rec. XII, 158 .	...	Quarries west of this village of black hornblendic rock: whence the great Tanjore bull, and other fine monoliths are said to have been raised.
	Ratnagiri . .	Mem. IV, 310.		
	Trichinopoly rock . .	Ditto, 367.		

MADRAS—*continued.*

QUARRY STONES—*continued.*

Mineral or Stone.	Locality.	Reference.	Other Minerals.	REMARKS.
LATERITE, *Lte.*	BELLARY— . .	...	ANT. CLY. COP. G. GRT. LD MAG. MAN OCHR. S SOP.	
	Sundur Hills . .	Man III, 549, Rec. XIX, 106.	...	Sub-ærial beds of this rock, formed by the alteration of hæmatitic talus debris, form terraces of considerable extent on the southern flanks of these hills.
	CHINGLEPUT—			
	Avadi Railway Station Ingawarpalliam . Kandur . . . Kunam . . . Palaveram . . Ponjur . . . Red Hills . Sripermatur . . Tinanur Ry. Station . Tirumangalam . Trivellur . .	Mem. X, 132 .	...	Quarries for laterite used as rough building stone, and very largely as road material, exist, or could be opened, at these places, and at many others off the general lines of traffic.
	GANJAM—			
	Chattarpur . . Gopalpur . .	Madras Mus. . Report on the Hill of Mahendragiri, Calcutta 1870. Ball., 22.	.	No survey has been made of the district: but there is no doubt that laterite, or lateritised rock is frequent along this part of the coast.
	GODAVARI— . .	.	C COR. D GAR. GRT. LIM. MI PLM. Q SAL. SND SUL. TRP.	
	Dúdúgut . . . Pentlum . . . Pungadi . . . Rajahmundry-Samalkot.	Mem. XVI, 248 .	...	These four areas of generally sandstone rocks, lying along the inland edge of the Godavari and coastal

MADRAS—*continued.*

QUARRY STONES—*continued.*

Mineral or Stone.	Locality.	Reference.	Other Minerals.	REMARKS.
LATERITE, *Lte.—contd.*	GODAVARI—*contd.* Dúdúgut, &c.—*contd.*			alluvial tract, give numerous stretches of laterite which is quarried in many places for coarse building stone and road material.
	KURNOOL— Rudrar . . . Siruvel . . .	Mem. VIII, 279, 80.	...	Not of any extent, but here, as in many other parts of the district, a product of decomposition in the neighbourhood of iron beds.
	MADURA— Manamadura . .	Rec. XII, 153 .	...	Typical laterite conglomerate occurs around all these places.
	Puganeri . .	Do, do		
	Serruvayal . .	Do, do.		
	Sivagunga . .	Do, do.		
	Shahkotai . .	Do, do. .	...	Laterite of good quality is largely quarried here.
	Shuragudi . .	Do, do.		
	MALABAR . . .	Dist. Man. .	...	Pretty generally distributed all over the low country: in fact, the most evident rock on the West Coast which is the country of laterite.
	NELLORE— Kavali . . . Naidupet . . . Nellore . . . Ramapatam . . . Rasanur . . . Salurpet . . . Tadda . . .	Mem. XVI, 86, 87, 179.	...	Largely used for road material and occasionally, as at Nellore itself, as good building stone.
	NILGIRI— Paikara R. . .	Mem. I, 235 .	...	Near this river, on the road from Ooty to Makurti, also in many other places on the plateau, but only local and in small patches; a product of decomposition of the country rock.

MADRAS—*continued.*

QUARRY STONES—*continued.*

Mineral or Stone.	Locality.	Reference.	Other Minerals.	REMARKS.
LATERITE, *Lte.—contd.*	PONDICHERRY— Red Hills . .	Mem. IV, 206 .	...	Entered here as a part of the chain of laterite patches extending along the Madras coast.
	NORTH ARCOT— .	...	CLY. GRT. OCHR SAL. SND. SOD. TRP.	
	Alikur . . . Ramagiri . . Sattavedu . .	Mem. X, 38; Rec XII, 204.	...	Lateritic conglomerate of extraordinary coarseness: the less coarse parts quarried for rough stone.
	PUDUKOTAI STATE— Arrimullum . . Aulangudi . . Kilvellikotai . . Pudukotai . . Urriur . . .	Rec. XII, 153 and 157.	...	Hard typical laterite conglomerate near the western boundary of the lateritic area. The famous old fort of Kilvellikotai is built entirely of laterite.
	SALEM— . . .	...	CHR COR. G GRT. MAG. SOP. TRP.	
	Shevaroy Hills .	Mem. IV, 261 .	...	Forms a capping on the Shervarayan and other highest points. A product of decomposition of ferruginous rocks.
	SOUTH ARCOT— Capper's Hill (Cuddalore). Verdachallum.	Mem. IV, 173.		
	SOUTH KANARA . .	...	...	Laterite of the West Coast; common in the low country.
	TANJORE— Gandarakotai . . Vallum.	Mem. IV, 168, 263; Rec. XII, 152.	Q. . .	Vast sheets of laterite and lateritic conglomerate occur west and south of Gandarakotai.

MADRAS—*continued.*

QUARRY STONES—*continued.*

Mineral or Stone	Locality.	Reference.	Other Minerals.	REMARKS.
LATERITE, *Lte.—concld.*	TRAVANCORE STATE—	..	AMB CLY. G GAR. GRT. PLM.	
	Warkilli . . .	Rec. XV, 92 .	...	Great part of the low country of Middle Travancore consists of laterite, much of it being a produce of decomposition of the country rock.
	TRICHINOPOLY— Strimustrum . .	Mem. IV, 206 .	...	Extensions of the Vallum conglomerates.
	Thungudi . .	Ditto, 265 .		
	Trichinopoly . .	Ditto, 263 .		
LIME-STONE, &c, *Lim* (Includes most marbles of different kinds, calcareous flag-stones, Kunkar or Ghutin, Travertine Also, for convenience, serpentines and alabaster.)	ANANTAPUR— . .		D GRT TRP	
	Gudipadu . .	Mem VIII, 82 .	..	Blue, bluish-grey, and black "Narji limestone."
	Khona Upalapad .	Rec. IV, 18 . .	...	White travertine, of recent formation, with vegetable impressions and included land-shells. Burnt into lime which is much valued by betel-chewers; 6 miles south of village.
	Raialcherravu . .	Mem VIII, 165, Dist. Man, 94.	...	Pale green and white limestone, also serpentine.

MADRAS—*continued.*

QUARRY STONES—*continued.*

Mineral or Stone.	Locality.	Reference	Other Minerals.	REMARKS
LIME-STONE, &c *Lim.—contd*	BELLARY— Gadiganur (S. E. of)	R. B. Foote	...	Grey and white banded crystalline limestone
	Huvina Hoddigalli (6 miles, and 12 miles S. E. of)			Grey crystalline limestone.
	Tornagal (S. of)			A bed of crystalline limestone between two trap flows
	COIMBATORE— Maddakarai	Mem I, 224, 246, Madras Jour Lit. and Sci, N S, III, 5	GRT	Crystalline limestone 5 miles S. W. of Coimbatore Pink and grey, approaching to white are the prevalent colors, well adapted for interior decoration takes a high polish.
	Pollam South and S E. of Karur	Mem. IV 272	GRT	Many bands of crystalline limestone Pure white fine and coarse grained marble A beautiful pink variety of close texture and very pure, occurs in many of the lands.
				Kunkar very common
	CUDDAPAH— Beddadur Hill	Mem VIII 200	TRT	West of Kondapuram Railway Station. Pale blueish grey in colour.
	Chigalmarri	Ditto, 52.		
	Cuddapah	Ditto,		Coarse grey flaggy limestones in neighbourhood.
	Dhur	Ditto		
	Kalsapad	Ditto, 230		Grey semi-crystalline.
	Nandiallampet	Ditto,	Ln	
	Narji	Ditto, 70		Flaggy, and thin-bedded limestone, grey, blue, nearly black, fawn-coloured, buff Largely quarried in construction of Madras Railway; also the black variety

MADRAS—*continued.*

QUARRY STONES—*continued.*

Mineral or Stone.	Locality.	Reference.	Other Minerals.	REMARKS.
LIME-STONE, &c., *Lim.,—contd.*	CUDDAPAH—*contd.* Narji—*contd.*			for ornamental purposes in Madras; takes a good polish. Best for interiors. "Narji stone."
	Ontamitta . .	Mem. VIII, 430.		
	Raialcherru . .	...	..	Serpentine limestone and serpentine, green colours.
	Reddipalli . .	Mem. VIII, 208 .	...	Very remarkable breccia of light-grey colour.
	Vaimpalli . .	Ditto, 361.		
	Wattalurkonda .	Ditto, 205.		
	GODAVARI—			
	Karteru . . .	Mem. XVI, 234—243.	SND. TRP. .	Quarries. Yellow-buff, and brownish-red, somewhat crystalline, occasionally magnesian, almost a dolomite, 12 to 14 feet in thickness. Calcareous sandstones at Dudkura. Fossiliferous limestone; somewhat magnesian.
	Pungadi . . .			
	KISTNA— . . .	.	D GAR. GRT. LTE. Q. SLT. SND.	
	Dachapalli (Palnád) .	Mem. VIII, 282 .	...	A vast development of limestone, in thick and thin beds, compact, of excellent quality and various colouring.
	Jaggayapetta .	Ditto, 295 .	...	Fine grey and variegated compact limestones.
	Kakeralla . .	Ditto, 231 .	...	Extensive beds of crystalline and sub-crystalline limestone.
	Melluvaga . .	Ditto, ,, .	...	Ditto ditto.
	Mukteala (on the Kistna).	Ditto, 298 .	...	Grey, or grey and white, compact flaggy limestone.

MADRAS—*continued.*

QUARRY STONES—*continued.*

Mineral or Stone.	Locality.	Reference.	Other Minerals.	REMARKS.
LIME-STONE, &c., *Lim.—contd.*	KURNOOL—			
	Banaganpilli (E. of) .	Mem. VIII, 52		
	Baadi Atmakur .	Ditto, ,,		
	Betamcherla . .	Ditto, ,,		
	Billum . . .	Ditto, 33	..	Flaggy grey limestones of good quality.
	Jorapur (E. of Kurnool).	Ditto, 166 .	.	Serpentine, pale-green and yellowish.
	Kurnool . . .	Ditto, 52.		
	Madavaram . .	Ditto, 166 .	Sop .	Serpentine limestone, white crystalline limestone.
	Marrivaimla (W. of.).	Ditto, 231.		
	Mutakula . .	Ditto, 231 .	Sop	
	Pagidala . . .	Ditto, 52		
	Potalapad . .	Ditto, 231 .	Sop.	
	MADURA—			
	Kilakarai . .	Mem. XX, 70—73	..	Here and along the coast eastward, marine shelly limestone and calcareous sandstone.
	Kokulam . .	Ditto, 19 .	Gr . .	Important beds of crystalline limestone of great beauty: of grey, grey and pink, pink and pink and green colours.
	Pambam . . .	Ditto, 70—74	...	Upraised (sub-fossil) coral reef.
	Pantalaguli . .	Ditto, 21 .		Same as at Kokulam.
	Rameswaram Island	Ditto, 70—74	...	Same as at Pambam.
	Shenkottai . .	Ditto, 23 .	Gr. . .	Crystalline limestone.
	Tirumal . .	Ditto, 19 .	...	Ditto ditto.
	Valimukkam . .	Ditto, 68 .	...	Marine shelly limestone, and calcareous sandstone.
	NELLORE—			
	Chundi . . .	Mem. XVI, 23 .	Cop. . .	Grey crystalline limestone.
	Pedda Arikatla .	Ditto, ,, .	.	Whitish sub crystalline limestone 8 miles N. by E. of Kunnigiri. *N. B.*—A good deal of lime is manufactured from the sub-recent shell beds in the backwater deposits; and from Kunkar which occurs only locally.

MADRAS—*continued.*

QUARRY STONES—*continued.*

Mineral or Stone.	Locality.	Reference.	Other Minerals	REMARKS.
LIME-STONE, &c., *Lim —concld*	SALEM— Shattambur	Mem. IV, 273	GRT.	Seven miles S. W. of Namakal. A fine show of grey, white and pink limestone of excellent quality
	Sunkagiri Drug	Ditto, ditto		Thin beds of grey crystalline limestone.
	TINNEVELLY— Karseri	Mem XX, 57	...	Calcareous tufa
	Kuddungkalam	...	.	Eleven miles N E. of Cape Comorin. Marine shelly limestones of fair quality.
	Samugarungapuram Sathankolam Sevandipatti	Mem. XX, 77		Great spreads of massive calcareous tufa of alluvial origin. Kunkar.
	Tutikorin	Ditto, 102	.	Rock coral, used for coarse building purposes
	TRICHINOPOLY— Assur	Man. III 456, Mem. IV, 94	..	Crystalline limestone of pale colours.
	Elanuthumangalam	Mem IV, 275.		
	Garudamungalum	Ditto, 116		The well-known Trichinopoly shell limestone or marble.
	Kalligudi	Ditto, 62	...	Marine coral limestone.
	Kalpatti	Ditto, 274		
	Karai	Ditto, 36		
	Kiranur	Ditto, 272	..	Crystalline limestone of pale colours.
	Konkanattam	Ditto, 120	...	Ditto ditto
	Maravatur	Ditto, 89		
	Muttum	Ditto, 276		
	Narasingapuram	Ditto, 272, 275		
	Nevelli	Ditto, 276		
	Odiam	Ditto, 91	..	Ditto ditto.
	VIZAGAPATAM— Borra Nilgalgunta.	Rec. XIX, 153	GRT	Crystalline limestone, pale coloured, close texture. Also remarkable caverns, with splendid displays of stalactitic and stalagmitic tufas.

N B—Concretionary and nodular calcareous tufa, travertine, or 'kunkar,' occurs in most districts; chiefly in those containing large spreads of cotton soil which it almost invariably underlies. It occurs also largely at the surface of most tracts of the more hornblendic rocks. R. B. FOOTE.

MADRAS—*continued.*

QUARRY STONES—*continued.*

Mineral or Stone.	Locality.	Reference.	Other Minerals	REMARKS.
SAND-STONES, *Snd* (Includes any sandy rock used for building, even calcareous sand-stones, flags also quartzites which are only indurated, sandstones Pebbly rocks).	ANANTAPUR— . BELLARY— .	}	.	No true sandstones occur in these districts the quartzites representing them are too hard to be dressed and are only used for rough buildings and revetments of tank embankments R B FOOTE.
	CHINGLEPUT— Conjeveram	Mem X, 132		Compact sandstone
	CUDDAPAH— .	Mem VIII .		Altered sandstones (quartzites) of various kinds are common in the hilly parts of the district, and are often used as good building stones, or even grindstones Occasionally these are weathered to [illegible] h an extent as t[illegible] ook like ordinary sandstones
	GODAVARI— Janampett (N N W. of Ellore).	Mem XVI 249 253		Very durable stone
	Peddapuram (7 miles N. W of Samulkotta)	.	.	Very good building stone, which of course requires selection. Similar sandstones are to be found on the plateau tracts bordering the edge of the alluvial coastal plain in the neighbourhood of Rajahmundry, Ellore, and Gollapilli
	Peddavegi (7 miles N. of Ellore).			Red sandstone, some of it of a bright vermilion colour, and well worth developing

MADRAS—*continued.*

QUARRY STONES—*continued.*

Mineral or Stone.	Locality.	Reference.	Other Minerals.	REMARKS.
SAND-STONES, *Snd.—contd.*	GODAVARI—*contd.* Tundkalpudi (14 miles N. N. E. of Ellore).	...	...	Buff, granular felspathic rock, of perfect durability. A most useful stone.
	KISTNA— Chebrolu (8 miles of S. E. of Guntur).	Mem. XVI, 78	..	Red and purple sandstones colours very handsome. Stone much esteemed by the Jains, as shown in old ruins. Largely quarried by the Public Works Department, and people generally.
	Palnad . . .	Mem VIII, 107, 121	Lim. . .	Altered sandstones (quartzites) very common in the hilly parts of this tract.
	Pavulur (2 miles N E. of Budavada).	Mem XVI, 69, 107		Hard greenish, or bluish-black calcareous sandstones, weathering brown. Largely quarried by the Public Works Department.
	Tungellamudi (8 miles E. of Guntur)	Ditto, 78 .		Same as at Chebrolu.
	KURNOOL— . .	Mem VIII . .		Altered sandstones (quartzites) very common in the hilly parts: very often admirable building stones.
	Yeldurti . .	Ditto, 283 .	...	Between this village and Tekur, in the low scarps to east of high road, a coarse felspathic grit is largely quarried for grindstones.
	MADURA— Ammagudi (4 miles N W. of Arrantangi)	Mem. XX, 37 .	..	Coarse flaggy grits, forming a scarp overlooking the valley of the Vellar. Quarried for local use.

MADRAS—*continued.*

QUARRY STONES—*continued.*

Mineral or Stone.	Locality.	Reference.	Other Minerals.	REMARKS.
SANDSTONES, Snd.—*contd.*	MADURA—*contd.* Kalakarai . .	Mem. XX, 70, 102	...	East of the village, and all along the 'sandstone quay' to Tonturai Point opposite Pámbam, remains of old quarries were noted.
	Sivagunga (2 miles S. E. of).	Ditto, 38, 102	...	Dark purplish-grey hard grits, with brown bandings: largely quarried.
	Valimukkam . .	Ditto, 68, 102	...	A great quarrying industry once existed here, large masses of calcareous gritty sandstone having been raised and shipped away, probably to the great temple at Rameswarum.
	NELLORE—Budavada (24 miles N. by E. of Ongole)	Mem. XVI, 69 .	.	Hard brown sandstones, quarried for local use.
	Kovur (N. of Nellore).	Ditto, 178.		
	Peddawarum . .	Ditto, ,, .	...	Coarse ferruginous grits.
	Razpudi, 17 miles N. N. E. of Ongole.	Ditto, 65 .		Flaggy beds of hard coarse shale (more of a sandstone than a shale), variegated with concentric bands of delicate red pink, mauve, purple and occasionally orange colours; often of great beauty. Flags quarried largely for building purposes.
	Vemavaram (14 miles N. E. of Ongole).	Ditto, 64 .	...	White flaggy shales similar to above.
	NORTH ARCOT—Alikur . . .	Mem. X, 75 .	...	Two miles S. E. of village; compact fine-grained sandstones, with concretionary purple bands. Fair quality.

MADRAS—*continued.*

QUARRY STONES—*continued.*

Mineral or Stone.	Locality.	Reference.	Other Minerals.	REMARKS.
SAND-STONES, *Snd.—contd.*	NORTH ARCOT—*contd.* Nagaloperam . .	Mem. X, 71 .	...	Dark purple coarse sandstones, cut into long troughs, S. E. of village.
	Sattavedu . .	Do, do. .	...	Compact greyish-buff, or reddish sandstone of good quality.
	Tettu . . .	Ditto, 69 .	...	Three miles W. S. W. of Sattavedu, bright red compact sandstone, quarried in large blocks.
	SOUTH ARCOT— Vellampalam (on the Gaddilam R). Velur (near Verdachellam).	Mem IV, 207 .	...	Compact, moderately fine-grained sandstones; used for water troughs, &c. Easily quarried.
	TANJORE— Vallum . . .	Ditto, 167 .	...	Also near Tanjore itself.
	TINNEVELLY— Panamparai . .	Mem. XX, 102 .		Quarries. Fine cream-coloured or brownish calcareous sandstone, used in constructing the great Gothic churches at Megnanapuram and Mudalur, also the great temple at Tiruchandur on the coast S. of Tutikorin.
	Vedanattam . .	Ditto, 66, 102		Quarries; 8 miles N. by W. of Tutikorin. Fine gritty calcareous sandstones, largely employed as building stone at Tutikorin. Fine cattle troughs, &c., made at the quarries.
	TRAVANCORE STATE— Killiur . . .	Rec. XVI, 28 .	...	S. and N. N. W of this place; dark and purplish hard grits. Good, but little used.

MADRAS—*continued.*

QUARRY STONES—*continued.*

Mineral or Stone.	Locality.	Reference.	Other Minerals.	REMARKS.
SAND-STONES, *Snd.—contd.*	TRAVANCORE STATE—*contd.* Warkilli	Rec. XV, 98	...	Occasional beds of sandstone in the cuttings and cliffs of the hills here.
SLATE, *Slt.* (Includes flags, though these are cleaved, like slates.)	CUDDAPAH— Budvel	Mem. VIII, 139	SND LIM	There are no true slates in the Madras Presidency, that is, approaching the roofing slate of commerce. Slabby slates are procurable, but not of large size. Occasionally slaty flags of tolerable size are obtainable.
	Howhoblum			
	Nullamallai Mts.			
	Ontamitta			
	KISTNA— Palnad	Ditto, 107	..	Ditto ditto
	KURNOOL— Kumbum	Ditto 227	..	Ditto ditto.
	Nullamallai Mts.			
TRAP, &c., *Trp.* (Includes basalt, whinstone, and other compact massive dark-coloured rocks. All volcanic rocks.)	ANANTAPUR— Handi Anantapur	Man III, 538	..	Trap. (Diorite greenstone), from great dykes in neighbourhood.
	Tadamurri			
	BELLARY— Adwani	Rec. XIX, 108		Trap dykes.
	Copper Mountain			
	Guti	...	...	Ditto.
	Oblagundi Gorge (Sandur Hills).	Rec. XIX, 104	...	Beds or sheets of trap.
	Papanaykanhalli Ravine.	Ditto, 105	...	Ditto.
	Ramandrug	Ditto, "	..	On eastern slope.
	Tungabudra, R.	Ditto, 108	...	North of Sandur Hills
	Virapur Ry. Stn.	Ditto, "	...	Trap dykes.

MADRAS—*continued.*

QUARRY STONES—*continued.*

Mineral or Stone.	Locality.	Reference.	Other Minerals.	REMARKS.
TRAP, &c, *Trp.—contd.*	CHINGLEPUT—			
	Alikur and Korteliar Hills.	Mem. IV, 130 .	...	*Black trap dykes.*
		...	...	Greenish grey trap.
	Naggaripett . .	...	...	Many trap dykes in this neighbourhood.
	CUDDAPAH—			
	Beddadur Hill . .	Mem. VIII, 198 .		
	Chittravutti R. . .	Ditto, 169 .		
	Jutur . . .	Ditto, 196 .	...	Numerous and great beds and sheets of contemporaneous and intrusive trap.
	Papugni Valley .	Ditto, 160 .		
	Upalpad Plateau, (Western slopes)	Ditto, 198 .		
	GODAVARI—			
	Karteru . . .	Mem. XVI, 241 .	LIM. SND. .	Beds and sheets of trap.
	Pungadi . . .			
	KISTNA—			
	Bellamkonda . .	Ditto, 42 .	.	Plexus of trap or greenstone dykes.
	KURNOOL—			
	Dhone . . .		...	Trap dykes.
	Jeldurga . .	.	.	Trap sheet.
	Kapatral . .	..	...	Dykes.
	Paipali . . .	.	.	Ditto.
	Pendakul .	..	.	Ditto.
	Polekul . . .	..	..	Great trap dyke.
	Puspulla Valley .	...	...	Numerous beds and sheets of trap.
	Sunnagundla Drug .	...	...	Trap dykes.
	Ullur . . .	..		Trap sheet, 10 miles E. N. E. of Kurnool.
	NELLORE—			
	Jelakabad . .	Mem. XVI, 165 .	..	Greenstone or diorite.
	Kandra . . .	Ditto, ,, .	...	Ditto ditto.
	Paremkonda . .	Ditto, 168 .	...	Trap dykes.
	Pokrapali . .	Ditto, 167 .	...	Ditto.
	Tumoi . . .	Ditto, ,, .		Ditto.
	Ullapuram . .	Ditto, ,, .		Ditto.
	NORTH ARCOT—			
	Arcot . . .	Dist. Man., 6 .	...	Great plexus of trap dykes.
	Sholingar . .	..	..	Ditto ditto. *N. B.*—There is a tremendous development of trap dykes in this district, which extends northwards by Chittur into the south-western part of the Cuddapah district.

MADRAS—*concluded.*

QUARRY STONES—*concluded*

Mineral or Stone.	Locality.	Reference.	Other Minerals.	REMARKS.
TRAP, &c., *Trp.—contd.*	SALEM—			
	Athur (S. of) . .	Mem. IV, 329 .	...	Paithur hills, dykes.
	Chinna Salem .	..	...	Trap dykes.
	Namakal (N. of) .	...	...	Long trap dykes running N. N. E. from Nainhamellai hill.
	Mulliakerra Hill .	...	...	Dykes, 18 miles W. of Salem.
	Tangrikota . .	...	...	System of great W N. W.—E S. E. dykes in the Baramahal.
	SOUTH ARCOT—			
	Agaram Kotalam .	Mem. IV, 334 .	...	Trap dykes.
	TRICHINOPOLY—			
	Korawadi . .	Mem IV, 329 .	...	Numerous, and great trap dykes.
	Nunnay . . .			
	Pulliur . . .			
	Tuludur Tukuri .			
	Volkondapuram .			

NORTH-WEST PROVINCES AND OUDH.

IMPORTANT MINERALS.

Coal, *C.* Iron Ores, *I* Gold, *G.* Petroleum, *Oil.* Salt, *Sal.*

Mineral or Stone.	Locality.		Reference.	Other Minerals.	REMARKS
COAL, *C.* .	BIJNOR—	Tertiary coal in Siwalik beds.			
	Najibabad . .		Gazetteer, N. W P. X, 291.	LIM. SND. .	Traces of lignite.
	DEHRA DÚN—		...	GYP. PHO. SLT. SND.	
	Kalawala Pass .				
	Kheri „ .		Man. III, 102 .	...	Ditto ditto
	Timli „ .				
	GARHWÁL—		...	ASB. COP. G GYP. I.	
	Dhela R. .		Gazetteer X, 291 .	LD. LIM. PLM SLTE SND. SOP. SUL.	Traces of coal or lignite, from one inch to two inches in thickness.
	KUMAUN—		Mem. XXIV, 34 .	ALM. ARS. COP. GRT GYP. LD. LIM. OIL.	
	Bhamauri . .		Gazetteer, as above	PLM. SLTE SND.	Traces of lignite on the Bara Kheri pass, seam 4 inches thick.
	Bhim Tal . .		Ditto, ditto .	...	Traces of true Peat.
	Ráuibagh . .		Ditto, ditto .	.	Traces of lignite.

N.B.—There is no promise of workable coal in this part of the Himalayan region The black slaty shales of Mussuri and other places belong to a much older series; but they, too, are of no account.

NORTH-WEST PROVINCES AND OUDH—*continued.*

IMPORTANT MINERALS—*continued.*

Mineral or Stone.	Locality.	Reference.	Other Minerals.	REMARKS.
COAL C—*contd*	MIRZAPUR—	Gazetteer, XIV, Pt 2, 18, 56.	GRT. JD. LIM. SND.	Gondwana coal.
	Singrauli	Man. III, 88; Rec. VI, 16.		Small extension of the Sone area of coal-bearing rocks, in which there appear to be several outcrops of coal, in which also the Kota colliery was worked for some years. Communication difficult. "The Mirzapur coal area is bounded on the north by the Aundhi hill in Lat. 24° 12′ 21″ and Long 82° 43′ 51″, on the south by the Ballia Nadi; on the east approximately by the Rehand river, while on the west, it extends into Rewah. The coal has been acknowledged to be good. It burns freely with a clear flame, leaving a white ash; but it will not coke by ordinary means." Gazetteer, N. W. P. XIV, pt. 2, p. 57.
IRON ORES	BANDA—	Man III, 393; Mem II, 89.	CLY. D GRT LIM. SND.	In the Bijawar series. Lateritic: poor. Dense sub-crystalline, red hematite, in an impure dry clay; in good quantity, easily worked. Fuel scarce.
	Deori Gobarhai Khirani	Gazetteer I, 97	...	Ore of fine quality; "works managed by a company of *lohars* (blacksmiths); they pay

NORTH-WEST PROVINCES AND OUDH—*continued.*

IMPORTANT MINERALS—*continued.*

Mineral or Stone.	Locality.	Reference.	Other Minerals.	REMARKS.
IRON ORES, *I.—contd.*	BANDA—*contd.* Deori, &c.—*contd.* .			nothing to the Zemindars for the right of digging the raw ore, but a sum of R4 per kiln per season.
	GARHWAL— . .	Man. III, 406; Gazetteer X. 262.	ASB. C COP G. GYP. LD. LIM. PLM. SLTP SND. SOP SUL.	Several attempts at ironworks under European management; ultimate failure for various reasons; success very questionable.
	Buchursaiun . .	Rec II, 88, IV, 20.		Native mine at Duguru.
	Chandpur . .			Mines at Kúsh and Rajbunga. Hematite.
	Dussoli . .			Mines at Churbung and Mok.
	Idiakot . . .		.	Mines at Dandatoli and Pipuli.
	Lobha . . .		LIM SLT. .	Rich hematite, raised in quantity.
	Nagpur .		COP LD. SUL	Mines at Búkhunda, Gilet and Jakhteli.
	Painu .		.	Mines at Chelia.
	Pokri . . .		COP. .	Mines.
	KUMAUN— . . Agar	Rec II 87, IV, 19.	ALM ARS. C COP. GRT GYP LD. LIM. OIL. PLM. SLTE. SND. SUL.	Mines at Gulla, Nathna Khan, and Sutbunga. Agar Putti is very rich in iron ore, almost every village having its mine.
	Chaugurka . .	Ditto, ditto .	..	Worked in some places.
	Darun . . .	Ditto, ditto .	..	Mine at Diguria.
	Dechauri . .	Rec. VII, 15 .	...	Ore abundant, of good quality.
	Dhuniakot . .	Rec. II. 87, IV, 19	.	Mine at Semulkha.
	Giwar . . .	Ditto, ditto .	COP .	Occurs near the villages of Burigaon, Gudi, Khutsari, Melchaur, Simulkhet and Tilwara.
	Kaladhungi . . .	Rec. VII, 15 .	..	Ore abundant, variable in quality.

NORTH-WEST PROVINCES AND OUDH—*continued.*

IMPORTANT MINERALS—*continued.*

Mineral or Stone.	Locality.	Reference.	Other Minerals.	REMARKS.
IRON ORES, *I.—contd.*	KUMAUN—*contd.*			
	Khairna	Rec. VII, 15	...	Not of much promise.
	Kharai	Rec. II, 87; IV, 19.	COP.	Mine at Lobe.
	Khúrpatal	Ditto, ditto	...	Said to have been worked by the Kumaun Iron-works.
	Kutoli	Ditto, ditto		
	Lukkhunpur	Ditto, ditto		
	Ramgarh	Rec. VII, 16	...	Under this heading are included Losh-gani, Natna Khan, Páhli and Par-wara Micaceous hematite, rich and abundant, might easily be worked. Mines are also said to occur at Diguria and Julal.
	Tulli Rao	Rec. II, 87	...	Mines at Mungla-lekh; good ore, raised in quantity in 1869.
	LALATPUR—Girár	Gazetteer I, 323	COP. GRT. LIM. SLTE. SND. SOP.	
	Pura	...	...	Confluence of the Jumai and Betwa.
	Salda	...	...	Pergunnah Marau-ra; hematite, from which soft iron is smelted and exported largely to Ságar.
GOLD, *G.*	GARHWAL—	Man. III, 216; Mem. III, Art. IV, 179; Gazetteer X, 276	ASB. C. COP. I LD. LIM. PLM. SLTE SND. SOP. SUL.	
	Alaknanda R.	...	GYP.	Auriferous sands.
	Benigunga	...	.	Ditto.
	Kedarnath	As. Researches, XVIII, 236.	...	Trace, in granite.
	Pindar	...	...	Tributary of the Alaknanda. Sands.
	Sona	...	...	Sands.

NORTH-WEST PROVINCES AND OUDH—*continued.*

IMPORTANT MINERALS—*continued.*

Mineral or Stone.	Locality.	Reference.	Other Minerals.	REMARKS.
GOLD, *G.*—*contd.*	MORADABAD— Amangarh . . Barapura . . Dhela R. . . Koh . . . Kotdwar . . . Kot Kadir . . Lakher Ghat . .	Journ. As. Soc. Ben., II, 265.	LIM.	All these localities, except that of the Dhela river, are tributaries of the Ramgunga. Gold dust: small in quantity; but more abundant in the sands of the Koh.
PETROLEUM, *Oil.*	KUMAUN . . .	Man. III, 132; Rec. II, 89; IV, 21.	ALM. ARS. C. COP. GRT. GYP I. LD. LIM. OIL. PLM. SLT SND SUL.	
	Summit of Range between the Sarju and Ramgunga.	Asiatic Researches, XVIII, 230.	LIM.	Bitumen exudes from crevices in limestone rocks.
	Gowarseo . . . Kotgaon . . .	Rec. II, 89; Gazetteer X, 297.	...	Bitumen; in the neighbourhood of these villages south of Paori, near the top of large cliffs; and is worked by the natives, by means of a scaffolding suspended from the summit.
SALT, *Sal.*	AZAMGARH . . Mahul.	Gazetteer XIII, Pt. I, p. 58.	CIY. NIT.	In this Pargunnah, especially in the Didarganj tappa, considerable deposits of salt-earth occur.
	BULANDSHAHR . . Kali Nadi . .	Man. III, 491 . Gazetteer III, 35 .	LIM. NIT. . SOD. . .	Earth salt. Small saline patches along banks of this river
	Khadir Lands . .	...		These lands form a tract adjacent to the Jumna, in the western corner of the Dadri Pargunnah. On this tract, the 44 villages—the largest producing one at the

NORTH-WEST PROVINCES AND OUDH—*continued.*

IMPORTANT MINERALS—*concluded.*

Mineral or Stone.	Locality.	Reference.	Other Minerals	REMARKS.
SALT, *Sal.*—*contd*	BULANDSHAHR—*contd* Khadir Lands—*contd*			time having been Mubárakpur — situated on it having had 319 salt works, producing 413,300 maunds of salt, before salt manufacture was prohibited.
	CAWNPORE .	Journ As. Soc., Ben III, 136.	CLY LIM	Earth salt

N B—There is no rock salt All the salt that used to be made in the North Western Provinces was from earth salt, which is most likely common enough near most of the rivers in the alluvial districts, and in the soils around most old villages in the same country

MISCELLANEOUS MINERALS

Alum, *Alm.* Antimony Ores, *Ant* Arsenical Minerals, *Ars* Asbestus, *Asb* Bismuth and Cobalt Ores, *B C* Borax, *Bx* Chrome Ores, *Chr.* Copper Ores, *Cop* Corundum, *Co* Gypsum, *Gyp.* Lead Ores, *Ld.* Magnesia Minerals, *Mag.* Manganese Ores, *Man* Mica, *Mi* Natron, *Nat.* Nitre, *Nit.* Ochres *Ochr.* Phosphates, *Pho.* Platinum, *Plt.* Plumbago, *Plm* Soapstone, *Sop.* Soda Salts, *Sod* Sulphur, *Sul* Tin Ores, *Tn* Zinc Ores, *Zn*

Mineral or Stone.	Locality.	Reference	Other Minerals	REMARKS.
ALUM, *Alm*	KUMAUN— Jak . .	Man III, 434, Gazetteer X, 297	ALM. ARS. C COP. GRT GYP I SND LD. LIM OIL PLM. SLTE SND SUL.	On the road from Naini Tal to Khairna Efflorescence from pyritous shales No manufacture known, but natural alum collected for medicinal purposes.
	Kosi R			Below Almorah, efflorescence on micaceous schist
ARSENICAL MINERALS, *Ars.*	KUMAUN— Munsiari . .	Rec. II, 88 . .	Ditto .	Northern part of the district, yellow arsenic (*hurtal*): only small quantities brought down to the Bagesar fair.

NORTH-WEST PROVINCES AND OUDH—*continued.*

MISCELLANEOUS MINERALS—*continued.*

Mineral or Stone.	Locality.	Reference.	Other Minerals.	REMARKS.
ASBESTUS, *Asb.*	GARHWAL—Ukhimath.	Gazetteer X, 294.	C. COP. G. I. LD. LIM. PLM. SLTE. SND. SOP. SUL.	In a hill north of, and a short distance from, village; said to be of very good quality: used as a dressing for wounds, and as wick for oil lamps. Worthy of enquiry.
COPPER ORES, *Cop.*	GARHWAL	Man. III, 268, Rec. II, 88; Gazetteer X, 279.	ASB. C. G I. LD. PLM. SLTE. SND SOP. SUL.	The mines of copper in Kumaun and Garhwal have never been of much practical value either as a source of supply for local consumption or as offering a valuable return to labour and capital. Gazetteer, N. W. P., X, 279.
	Agar Sera	...	...	In the Lobha patti; old mines, thin strings of vitreous and purple copper ore.
	Dewalgarh	...	LD.	Said to have yielded largely in former times. Copper pyrites, grey and vitreous copper.
	Dhanpur	...	LD.	
	Dhobri	...	...	
	Nagpur	...	...	Several old mines here, deserted.
	Pokhri	...	...	Centre of a group of mines, three of which were the scene of the experimental mining carried out by Government under Mr. Wilkins in 1838.
	Tornakoti	...	...	Same as at Agar Sera: mine said to be favourably situated for wood and water.

NORTH-WEST PROVINCES AND OUDH—*continued.*

MISCELLANEOUS MINERALS—*continued.*

Mineral or Stone.	Locality.	Reference.	Other Minerals.	REMARKS.
COPPER ORES, *Cop.—contd*	KUMAUN . . .	Man. III, 267; Rec. II, 87; IV, 19; Gazetteer X, 279.	ALM. ARS. C. GRT. GYP. I. LD. LIM. OIL. PLM. SLTE. SND. SUL.	
	Beler . . .	..	...	Old mines.
	Chinkalkolli . .	.	...	Ditto.
	Ganguli . . .	...	.	Bujál mine, and Rethaiat mine (Belpatti) Fudiali mine (Altragaon patti), Rai mine, and Tamba Khan (Ganguli patti). The Rai mine is said to be the most important in Kumaun.
	Giwar . . .	.	I . .	Small mine.
	Gurung . . .	.		Old mines.
	Kharahi . . .	.	I . .	Gaul mine.
	Sira . . .	..	...	Noted for its copper mine in the Barabisi patti.
	LALATPUR— Saurái . .	Rec. I, 16, Gazetteer, I, 323.	GRT. I. LIM SLTE. SND TRP.	Mansaura pargunnah Lode not fixed, but rolled lumps of copper ore in old pit.
GYPSUM, *Gyp.*	DEHRA-DÚN . .	Man. III, 453, Mem. III, Art. IV, 177.	C. OCHR. PHO SLTE. SND.	
	Jari Pani . . Nagal. Ranon. Sahansadhara.	..	...	Not in much quantity at these places; most likely a product of infiltration in recent times.
	GARHWAL— Alaknanda R. . .	Gazatteer X, 294.	ASB. C. COP. I. LD. LIM. PLM. SLTE. SND SOP. SUL.	
	KUMAUN— Chhakata Pargunnah . .	...	ALM ARS. C. COP. GRT. I. LD LIM. OIL. PLM. SLTE. SND. SUL.	

NORTH-WEST PROVINCES AND OUDH—*continued.*

MISCELLANEOUS MINERALS—*continued.*

Mineral or Stone.	Locality.	Reference.	Other Minerals.	REMARKS.
GYPSUM, *Gyp.—contd.*	KUMAUN—*contd.* Nihal Bridge . .	Rec. XXII, 137 .	...	Between Nihalpur and Dhapla village. Estimated amount 838,500 maunds, or 37,430 tons; a tufaceous sort of deposit of recent formation from springs.
LEAD ORES, *Ld.*	GARHWAL . . .	Man. III, 308; Rec. II, 88; Gazetteer X, 290.	ASB. C G. GYP. I. LIM. PLM SLTE SND. SOP. SUL.	"The lead mines in the Himalayan Districts of the N.-W. P. appear to be situated in localities difficult of access; several of them are worked to a small extent by the inhabitants for local purposes." Man. III, 308.
	Dhanpur . .	Sel. Rec. Govt. of India, XVII, 74.	COP. . .	Galena. Ore said to be abundant, and mine favourably situated for working.
	Kurrakot . .	Ditto, ditto .	..	Jak mine, Badhun rgunnah.
	Nagpur . . .	...	COP LIM. SLTE.	O mine.
	Tachirda . .	...	...	Worked, but not extensively.
	JHANSI— Jhansi Cantonments .	Man. III, 299 .	..	Extent and nature of deposit not known; but specimens of Galena yielding 19 oz. 12 dwts. of silver to the ton were found on banks of stream.
	KUMAUN . . .	Man. III, 308; Mem. III, Art. IV, 179.	ALM. ARS. C COP. GRT. GYP. LIM. OIL. PLM. SLTE. SND. SUL.	
	Gaul . . .	...	COP. .	Karahi patti; Galena in limetsone.

NORTH-WEST PROVINCES AND OUDH—*continued.*

MISCELLANEOUS MINERALS—*continued.*

Mineral or Stone.	Locality.	Reference.	Other Minerals.	REMARKS.*
NITRE, *Nit.*	ALLAHABAD— Doab	Man. III, 500; Gazetteer VIII, pt. 2, p. 11.	LIM.	Saltpetre plains, common in western parts.
	Sikundra	...	...	Common in eastern half of this pargunnah.
	AZAMGARH— Atraulia Kauria. Mahul.	Gazetteer XIII, pt. 1, p. 58.	CLY. SAL.	The production of saltpetre in these pargunnahs was prohibited by the Customs Department on account of the prevalence of salt (chloride) soil from which salt might be manufactured
	BALLIA—	Gazetteer XIII, pt. 3, p. 66	SOD. LIM	Two refineries.
	Bansdih			Ditto.
	Behra.			Ditto.
	Chichor.			465 crude saltpetre factories in the district; the quantity usually manufactured is estimated at 16,475 maunds per annum. Most of the factories are in the Kharid and Sikandarpur pargunnahs. The quantity of saltpetre refined in the district was estimated at 5,000 maunds in 1884.
	BULANDSHAHR— Khurja pargunnah Pahasu.	Man. III, 500; Gazetteer III, 38-40.	LIM. SAL. SOD.	"Saltpetre is to be found in almost every village of the district, in more or less quantities, and the villages capable of being worked for this substance must be some hundreds in number. In 1876, 95 factories producing crude saltpetre, and two refineries."

NORTH-WEST PROVINCES AND OUDH—*continued.*

MISCELLANEOUS MINERALS—*continued.*

Mineral or Stone.	Locality.	Reference.	Other Minerals.	REMARKS.
NITRE, *Nit.* —*contd.*	ETAWA . . .	Gazetteer IV, 532	LIM. . .	Leases, R16 to R18 per factory
	GORAKHPUR . .	Gazetteer IV, 345	LIM . .	A large quantity of saltpetre is made in the district.
	MAINPURI . .	Gazetteer IV, 532	LIM . .	Leases, R16 to R1 per factory
	MEERUT—Bagpat pargunnah	Gazetteer III, 249	LIM SOD. .	A little saltpetre was manufactured in the Meerut District in 1876. There were about 150 factories, producing 150 to 200 maunds. Previous to 1867, a refinery was worked at Harpur.
PHOSPHATES. *Pho.*	DERA DUN— . .	...	C GYP. SLT SND.	
	Mussuri . .	Rec XVII, 198		Phosphatic nodules in black clay-slates near Mussuri.
PLUMBAGO, *Plm.*	GARHWAL— Karnpraiag road . .	Man III, 56, Gazetteer X, 292.	ASB C COP G GYP I LD LIM SLT SND SOP SUL.	Lohba patti, used as a dye.
	KUMAUN— Bamini Devi. . .	Ditto .	ALM. ARS C COP GRT. GYP LD. LIM OIL. SLT SND SUL	In the spur facing Almora, on the Lohughat road.
	Garjoli . . .	Ditto . .	...	Near Balti.
	Kalimatia hill . .		.	North of Almora.
	Palsini . . .	Ditto . .	.	The graphite of Garhwal and Kumaun is not promising in quantity or quality.

NORTH-WEST PROVINCES AND OUDH—*continued.*

MISCELLANEOUS MINERALS—*continued.*

Mineral or Stone.	Locality.	Reference.	Other Minerals.	REMARKS.
SOAP-STONE, *Sop.* (Includes steatite, pot-stone, and Talc (not mica).	GARHWAL . . .	Gazetteer, N. W. P., X, 294	ASB. C. COP. G. GYP. I. LD. LIM. PLM SLTE SND. SUL.	"A white saponaceous stone resembling and used for the same purpose as pipe clay is produced in many places"
	HAMIRPUR—Gauhari . .	Gazetteer, N. W P, I, 157.	GRT. LIM. .	Panwári pargunnah Owned by zemindars who levy R2,000 to R3,000 per annum from the stone-workers for the privilege of quarrying Made into toys, hookahs, pots vases, &c.
	JHANSI—G rari Palar . . .	Gazetteer, N. W P, I, 261.	GRT LIM TRP.	Six miles to the north of Jhansi. An inferior kind of soap-stone, preferably pot-stone.
SODA SALTS, *Sod.*	BALLIA—Bhadaon . . Kopachit. Lakhnesar. Sikandarpur.	Gazetteer XIII, pt. 3, p. 67.	NIT . .	Fifty factories for carbonate of soda (*sajji*) in these pargunnahs Outturn in 1884, estimated at 11,400 maunds.
	BULANDSHAHR—Arnia .	Gazetteer III, 38	LIM. NIT. SAL.	Carbonate of soda, called *Sajji*.
	Bidauli			Sulphate of soda, *Khari*
	Dankaur.			Sulphate of soda, also Sajji.
	Ganges Canal . .			All along this canal patches of Sajji, under the name of *reh.*
	Garabpur . .			Patches of *Sajji.*
	Gujarpur . .			Sulphate of soda.
	Jahangirabad . .			N. W. of, carbonate of soda.
	Kambakshpur . .			Sulphate of soda.
	Pahasu . . .			Carbonate of soda.
	Surajpur . . .			Carbonate and sulphate of soda.

N B.—These places of soda efflorescence occur in what are called the *Khadir* lands. The manufacture of sulphate of soda was prohibited owing to the large percentage of salt (Chlorine) contained in the *Khari* or sulphate of soda earth The *Sajji* lands are only used when native glass is made.

NORTH-WEST PROVINCES AND OUDH—*continued.*

MISCELLANEOUS MINERALS—*concluded.*

Mineral or Stone.	Locality.	Reference.	Other Minerals.	REMARKS.
SODA SALTS, *Sod.* —*contd.*	MEERUT— Khadir lands of the Hindan.	Gazetteer III, 249	NIT.	
SULPHUR, *Sul.*	GARHWAL— Biri R. . .	Man. III, 159; Gazetteer X, 293.	ASB. C COP G. GYP. I. LD. LIM. PLM. SLTE. SND. SOP.	Sulphur spring, two miles above junction with the Alaknanda R.
	Nagpur pargunnah .	...	...	Sulphur spring close to the snowy range, to N. E. of the Madh Maheswar temple.
	KUMAUN— Ganjia R. . .	Rec. II, 88 . .	ALM ARS C. COP GRT. GYP. I. LD LIM OIL. PLM SLTE SND	Munsiari tract, in bed of river, mixed with carbonate of lime or perhaps gypsum.
	Kathgodam . .	...	..	Sulphurous springs.
	Naini Tal . .	.	...	Sulphurous springs.
	Nargoli . . .	...	..	
	Ramgunga R. . .	..	..	Munsiari tract, as above.

GEM-STONES, &c.

Amber, *Amb.* Beryl, *Brl.* Diamond, *D.* Garnet, *Gar.* Jade and Jadeite, *Jd.* Quartz, *Q.* Rubellite, *Rbl.* Ruby, *R.* Sapphire, *S.* Spinel, *Spl.*

Minerals or Stone.	Locality.	Reference.	Other Minerals.	REMARKS.
DIAMOND, *D.*	BANDA— . . . Saya Lachhmanpur	Gazetteer I, 98 .	CLY. GRT. LIM SND	Diamond mine at this place which is the summit of a hill called Bindachal, about 14 miles from Panna, in the Badausa pargunnah. Only ¼ belongs to the British Government, and this is leased for Rs 125 per annum.

NORTH-WEST PROVINCES AND OUDH—*continued.*

GEM-STONES—*continued.*

Mineral or Stone.	Locality.	Reference.	Other Minerals.	REMARKS.
JADE AND JADEITE, *Jd.*	MIRZAPUR—Bhamni . .	Man. III, 517; Rec. VII, 51.	C. GRT. LIM.	Between this place and Kotamowa, and at top of Kurea Ghat, bands of jade interbedded with mica schist.
	Kisari . . .	..	..	Olive-green jade occurs N. W. of this village.
	Kurea Ghat.			

QUARRY STONES.

Clays, *Cly.* Granite, Gneiss, &c., *Grt* Laterite, *Lte.* Limestone, Marble, Kunkar, &c., *Lim.* Sandstone, *Snd* Slate, *Slt.* Trap, Basalt, &c., *Trp.*

Minerals or Stone.	Locality.	Reference.	Other Minerals.	REMARKS.
CLAYS, *Cly*	ALIGARH . . .		LIM. .	Bricks and pottery.
	AZAMGARH . .	Gazetteer XIII, 125.	SAL. . .	Pottery clays, polished black pottery with white patterns
	Nizamabad . .	Gazetteer XIII, 177.	.	Fancy pottery.
	BANDA— . . . Kol Garhaia.	Gazetteer I, 98 .	D. GRT. LIM.	Pipe clay is found in a pretty extensive deposit on the hill above this place, in Tarahwan pargunnah.
	CAWNPORE . .	Gazetteer VI, 42 .	SAL. . .	Brick clays are procurable in most parts of the district.
	FARUKHABAD—Fatehgarh . .	Cal Jour. Nat. Hist. Soc. II, 593; III, 152.	LIM. . .	Tiles.
	MUZAFFARNAGAR .	Gazetteer III, 488	LIM. . .	Brick and tile clays.
	RAMPUR . . .	Gazetteer IX, pt. 3, 34.	...	Glazed pottery, pale blue and green colours. The clay is said to be found only in a tank near the City of Rampur.

N.B.—Clays suitable for bricks are common all over the alluvial plains of these provinces; and are manufactured in most villages, or to a larger extent in the great towns. Pottery of any account appears to be manufactured only in the places mentioned; the Aligarh pottery, principally of black and red colours, is generally on show at the Railway station.

NORTH-WEST PROVINCES AND OUDH—*continued.*

QUARRY STONES—*continued.*

neral or Stone.	Locality.	Reference	Other Minerals.	REMARKS
GRANITE, &c., *Grt.* (Includes all fairly compact crystalline rocks; as gneisses of all kinds, generally of grey greenish or flesh colours. Not compact massive black or dark green rocks such as Basalt, Trap, &c.)	BANDA—Kalinjar hills.	Man III, 535, Gazetteer I, 95, 447	CL. D I .	Syenite, greenstone, &c., up to foot of the scarp which is of sandstone.
	HAMIRPUR	Gazetteer I 56	SOP	
	JHANSI	Ditto I, 261	SOP	
	KUMAUN	Ditto X, 296	...	At Almora, mica schist is used as a building stone, at Naini Tal clay schist is used. At Ranikhet, a pale coloured gneiss forms a handsome and lasting building stone
	LALATPUR	Ditto X, 323	COP I LIM SLTE SND IRP	
	MIRZAPUR—South of the Sone R	Ditto XIV, pt 2 16, 55.	C JD. LIM	
LIME-STONE, &c., *Lim.* (Includes Marbles of different kinds, calcareous flag-stones Travertine 'Kunkar,' or 'Ghutin.' And, for convenience, serpentines and alabaster)	AGRA—Panáhat Tahsil	Gazetteer VII, 468	SND	A form of tufaceous or travertine deposit (kunkar), called block kunkar, or *dant* by the natives of the district, is found in the Chambal ravines The nodular form of the same deposit is very commonly distributed all over the alluvial tracts of the North-West Provinces, and is generally used for making lime, or for road material.
	ALLAHABAD—Lawain	Ditto VIII, pt. 2, p 37	NIT.	Quarries for kunkar at this place in the Arail pargunnah. Inferior quality; principally used for road material.

NORTH-WEST PROVINCES AND OUDH—*continued.*

QUARRY STONES—*continued.*

Mineral or Stone.	Locality.	Reference.	Other Minerals.	REMARKS.
LIME-STONE, &c. *Lim.—contd.*	ALIGARH . . .	Gazetteer II, 388 .	CLY. . .	Kunkar quarries exist in considerable numbers all over the district, Block kunkur costs a rupee per hundred cubic feet to quarry, and 8 annas per mile for transport.
	BALLIA— . . .			
	Amdaria . . .	Ditto XIII, pt. 3, p. 23.	LIM. NIT. SOD.	Quarries for soft kunkar.
	Bánsdih . . .			
	Barágaon . .	...	...	Block kunkar in solid sheets of coherent rock.
	Bhadaon.			
	Chilkahar . .			
	Firozpur . . .	...	...	Soft kunkar.
	Hanumanganj . .			
	Lakhnesar . .	...	...	Block kunkar, as at Bhadaon.
	Phipria . . .			
	Sahatwar . .			
	Sannora . . .	...	...	Soft kunkar.
	Sihachaur . .			
	Sikandarpur . .	...	...	Block kunkar, as at Bhadaon.
	BANDA— . . .			
	Chhibun	Gazetteer I, 98 .	CLY. D. GRI. I.	Kunkar; burned for lime in this pargunnah.
	Guncha . . .	Ditto, ditto .	...	In the Pailáni pargunnah; blackish kunkar, met with in quantities, for road metal.
	Ken R. . . .	...	...	Kunkar for metalling roads, found in this river, in the Banda, Pailáni and Sihonda pargunnahs.
	Tarahwan . .	Mem. G. S. of I. II, 13.	...	300 feet of horizontal limestones, fine and compact like Solenhofen stone, but saccharine lustre, pale colours. Kunkar burned for lime in this pargunnah.

NORTH-WEST PROVINCES AND OUDH—*continued.*

QUARRY STONES—*continued.*

Mineral or Stone.	Locality.	Reference.	Other Minerals.	REMARKS.
LIME-STONE, &c. *Lim.—contd.*	BARRILLY— Chhura . . . Fatehganj, East .	Gazetteer V, 570	...	Kunkar is comparatively scarce; but it repays excavation at these places, at one or two places between Bareilly and Bhojupura, and at one village between Jahánabad and Richha.
	BASTI— Manaráma R .	Gazetteer VI, 608	...	The nodular form of kunkar is quarried in several places: in most of which it is soft clayey, and apparently more fitted for lime manufacture than for road material. Along the banks of this river, in the Manwarpara tappa of Nagar, it is found in a harder condition
	BENARES . . .	Gazetteer XIV, 27	...	Kunkar, burnt as lime.
	BUDAUN— Agol . . . Birhaula . . . Chakolar . . Masaúdpura . . Rasúla . . . Sikri Kasimpur .	Gazetteer V, 37	...	Kunkar quarried at these places, and at several others in the district. Used mostly for road metal.
	BULANDSHAHR— Akbarpur . . Farhadpur . . Jaurauli . . . Jhont . . . Lodhi . . . Madanpur . . Shahpur . .	Gazetteer III, 40	NIT. SAL. SOD.	Block kunkar, quarried at these places and used as building stone. Kunkar for metalling roads is found all over the district.
	CAWNPUR— Kandra . . . Maswánpur . . Tilsahri . . .	Gazetteer VI, 41	CLY. SAL. .	Kunkar, also occurs pretty fairly distributed all over the district. Quarries near the city of Cawnpur are becoming exhausted.

NORTH-WEST PROVINCES AND OUDH—*continued.*

QUARRY STONES—*continued.*

Mineral or Stone.	Locality.	Reference.	Other Minerals.	REMARKS.
LIME-STONE, &c. *Lim.—contd.*	ETA	Gazetteer IV, 33	...	Block kunkar is found throughout the district.
	ETÁWA— Ahneya nadi . . Chambal R. . . Jumna R. . . Puraha nadi . .	Gazetteer IV, 270	NIT. .	Block kunkar.
	FARUKHABAD— Girwa . . . Khalla . . . Mamápur . . Ramzanapur . . Ritaura . . . Saraian . . . Sohapur . . . Tálgrám . . . Ukhra . .	Gazetteer VII, 57	CLY. .	Block kunkar. Quarries
	FATEHPUR . .	Gazetteer VIII, pt 3 p 25		Kunkar is found in large quantities throughout the district.
	GARHWAL— . . Alaknanda R Lohba patti Nayár R.	Gazetteer X, 295 .	ASB C COP G. GYP I LD PLM SLTE SND SUL	Three ranges of limestone hills, north of the first river in Nagpur, running from Lohba patti to the Pindar R., and south of the Nagar. Likewise other small patches scattered through the district.
	GHÁZIPUR— . .	Gazetteer XIII, pt 2 p. 33 ·	...	Kunkar is found in all the upland parts of the district.
	GORAKHPUR— Ghagra R. . . Taraina R. . .	Gazetteer VI, 344	NIT. .	Kunkar scarce.
	HAMIRPUR . .	Gazetteer I, 157	GRT SOP. .	Kunkar.
	JAUNPUR . . .	Gazetteer XIV, pt. 3, p. 27.	...	Kunkar occurs in the upland parts of the district.
	JHÁNSI— . . .	Gazetteer I, 262	GRT. SOP. .	Kunkar obtainable all over the district.

NORTH-WEST PROVINCES AND OUDH—*continued.*

QUARRY STONES—*continued.*

Mineral or Stone.	Locality.	Reference.	Other Minerals.	REMARKS.
LIME-STONE, &c *Lim.—contd.*	KUMAUN— Bágeswar.	Gazetteer X, 295	ALM ARS. C COP. I. LD OIL. PLM SLTE SND. SUL.	Lime is manufactured from limestone between this place and Almora.
	Baitálghat	...	.	Rock limestone; from which lime is burnt, also as building stone.
	Bورarau			
	Charal			
	Chital (N. of Dwára hát)			
	Dhaiánirao			
	Dhikuli			
	Gunjia R	.	...	Calcareous tufa, kunkar.
	Jaiuli (Kharahi range)		...	Rock limestone.
	NAINI TAL—	.	GYP.	Calcareous tufa.
	Nihal nadi	.	.	Rock limestone.
	Ramnagar (Cart-road to).			
	Simalkha			
	Sira			
	Sor			
	LALATPUR	Gazetteer I 324	COP. GRT I SLTE SND. TRP.	Kunkar.
	MAINPURI	Gazetteer IV, 533	NIT.	Kunkar abundant and of good quality.
	MEERUT—	Gazetteer III, 248	NIT. SOD.	Kunkar.
	Ayádnagar			
	Brijnathpur	...	..	Hápur pargunnah.
	Chhajupur	...	..	Ditto.
	Dattiana	..	.	Ghaziabad tahsil.
	Faridpur	...	..	Garhmuktesar pargunnah.
	Malahra	...	...	Ditto ditto.
	Meerut	...	...	Sardhana tahsil.
	Nali Hasanpur	..	...	Hápur pargunnah.
	Nandpur	...	...	Ghaziabad pargunnah; block kunkar.
	Narainpur	...	...	Ditto ditto.
	Rájpur	...	...	Garhmuktesar pargunnah.
	Rasúlpur Dantla	...	...	Saráwa pargunnah.
	Sadullapur	...	...	Hápur do.
	Sikhera	...	...	Garhmuktesar pargunnah.
	Tibrot	...	...	Meerut pargunnah.

NORTH-WEST PROVINCES AND OUDH—*continued.*

QUARRY STONES—*continued.*

Mineral or Stone.	Locality.	Reference.	Other Minerals.	Remarks.
LIME-STONE, &c. *Lim.—contd.*	MIRZAPUR . . .	Man. III, 462; Rec. V, 19; VI, 42; Gazetteer XIV, pt. 2, p. 53.	C. Gr.	
	Bichu nadi . .	...	Ir. Snd. Q.	Dolomite, interbedded with serpentine.
	Bilwada . . .	...	...	Coarsely crystalline white limestone.
	Saipur . . .	...	...	On the right bank of the Rehr, a little below this village, white crystalline marble, with serpentine.
	Singrauli . .	...	C. . .	A few miles from this, on the road to Mirzapur. Pure white marble.
	Ubra Hill . .	...	...	White granular limestone.
	MORADABAD . .	Gazetteer IX, pt 2, p. 54.	G. . .	Kunkar is obtainable everywhere to the south of the Rámgunga, except in the Moradabad tahsil.
	Atrási . . .	.	..	Hasanpur tahsil. (Kunkar quarries.)
	Dhakia . .	.	..	Sambhal tahsil. (Kunkar quarries.)
	Gwál Khera .	..	...	Bilári tahsil. (Kunkar quarries.)
	Maghupura . .	.	...	Sambhal tahsil. (Kunkar quarries.)
	Mansurpur . .	...	...	Sambhal tahsil. (Kunkar quarries.)
	Mundia . . .	...	..	Bilári tahsil. (Kunkar quarries.)
	Parota . . .	..	..	Hasanpur tahsil. (Kunkar quarries.)
	Patái . . .	...	...	Hasanpur tahsil. (Kunkar quarries.)
	Tulwar . . .	...	...	Sambhal tahsil. (Kunkar quarries.)
	MUTTRA . . .	Gazetteer VIII, 57	Snd. .	Kunkar is abundant all over the district, but there is a great difference in the quality of what is got east and west of the Jumna; that from the east being larger, harder, of a good ashy blue colour, and in thicker strata.
	Sádabad tahsil .	...	...	Block kunkar.

NORTH-WEST PROVINCES AND OUDH—*continued.*

QUARRY STONES—*continued.*

Mineral or Stone.	Locality.	Reference.	Other Minerals.	REMARKS.
LIME-STONE, &c. *Lim.—contd.*	MUZAFFARNAGAR	Gazetteer III, 487	CLY.	Kunkar for road metal is scarce.
	Jánsath tahsil	...	...	Only one quarry.
	Shámli do.	...	...	Two fair quarries.
	Soláni R.	...	...	One quarry in the Muzaffarnagar tahsil.
	SAHÁRANPUR—			
	Bájúhari	Gazetteer II, 175.		
	Dhulahera	...	...	Sarsáwa pargunnah. (Kunkar pits, &c., of good quality.)
	Kumhárhera	...	...	Sarsáwa pargunnah. (Kunkar pits, &c., of good quality.)
	Mánikpur	...	..	Sultanpur pargunnah. (Kunkar pits, &c., of good quality.)
	Raghunathpur	...	...	Nakúr pargunnah. (Kunkar pits, &c., of good quality.)
	Telipura		.	Sultanpur pargunnah (Kunkar pits, &c., of good quality.)
	Tikraul	.	...	Rampur pargunnah. (Kunkar pits, &c., of good quality.)
	Zainpur	...	..	Nakur pargunnah. (Kunkar pits, &c., of good quality.)
	SHAHJAHANPUR	Gazetteer IX, 58	...	Kunkar.
SAND-STONE, *Snd* (Includes any sandy rock used for building, even calcareous sandstones. Flags; also quartzites which are only indurated sandstones. Pebbly rocks.)	AGRA—			
	Baghaur	Man. III, 540; Mem VII, 116 Gazetteer VII, 460	LIM.	Valuable quarries of red and white sandstone; in the Khairagarh tahsil.
	Bandraoli	...	..	In the Kiraoli tahsil. red sandstone, inferior to the stone of the Khairagarh tahsil.
	Basai-Jagner	...	.	Valuable quarries of red and white sandstone, in the Khairagarh tahsil.
	Bidhauli	...	...	Hill in the Khairagarh tahsil, yielding best mill-stones, oil-presses, sugar-mills, &c.
	Chandsaura	...	...	Common stone.
	Dhanauli	...	...	Red and bluish stone, too hard for general masonry.
	Dhanina	...	...	Red and white sandstone; Khairagarh tahsil.
	Ghaskáta	...	...	Ditto ditto.
	Kareki	...	...	Ditto ditto.

NORTH-WEST PROVINCES AND OUDH—*continued.*

QUARRY STONES—*continued.*

Mineral or Stone.	Locality.	Reference.	Other Minerals.	REMARKS.
SAND-STONE, *Snd.—contd.*	AGRA—*contd.* Meoli . . .	...	...	Hill in Khairagarh tahsil; yielding mill-stones, &c.
	Nasana . . .	...	...	Red and white sandstone.
	Ninwara . . .	...	...	Red and bluish stone, too hard for general building purposes.
	Noni . . .	...	...	Hill in Khairagarh tahsil, yielding mill-stones, &c.
	Pahari Kalán . .		...	Common stone.
	Sikri . . .	...	...	Kiraoli tahsil, red sandstone, inferior to that of Khairagarh.
	Tántpur . . .		...	Valuable quarries of red and white sandstone, in Khairagarh tahsil.

N.B.—The more valuable quarries, those for instance at Tántpur, Basai-Jagner, and Baghaur, are worked by members of the carpenter (Barhai) caste. Each man pays the lord of the manor a seignority which, according to the locality and the colour of the stone, varies from R3½ to R4½ yearly. The price of fine sandstone at the quarry itself, is for the white or grey variety R7 and for the red variety R5 or 6 per hundred maunds. The price at Agra of the best stone from Khairagarh is, for the grey variety, about R50 or 52 the hundred maunds, for the red about R34 to 35. Gazetteer, N. W. P.

	BANDA— . . . Benipur Pali.	Gazetteer I, 96 .	CLY D. GRT I LIM.	A well-known quarry in Chhibun pargunnah whence large quantities of stone are sent to Allahabad, &c.
	Bhaunri . . .	...	...	Quarry in Tarahwan
	Gulrampur . .	...	...	In Badausa pargunnah; a small trade.
	Kalinjar . . .	...	...	Badausa pargunnah; noted for its export.
	Khoh . . .	...	...	Tarahwan pargunnah, quarries.
	Khohi Sitapur . .	...	...	Ditto ditto.
	Kol Garhaia . .	...	...	Ditto ditto; the best of the Tarahwan stones.
	Parridpur . .	...	...	Ditto ditto.
	Rahantia . .	...	...	Ditto ditto.
	Rasin . . .	...	...	Badausa pargunnah; large export.
	Rauli.			

NORTH-WEST PROVINCES AND OUDH—*continued.*

QUARRY STONES—*continued.*

Mineral or Stone.	Locality.	Reference.	Other Minerals.	REMARKS.
SAND-STONE, *Snd.—contd*	BIJNOR . . .	...	C. LIM. .	Sandstones occur over the hilly northern edge of the district.
	DEHRA DUN— Chakrata . .	Gazetteer X, 296 .	C GYP. PHO.	Quartzites frequent, which often give good building stone.
	Mussuri . . .	...	PHO. .	Sandstones, and quartzites frequent at base of hills.
	Siwalik Range . .	...	...	Sandstones frequent, the range is mainly made up of sandstones.
	GARHWAL AND KUMAUN.	Mem. XXIV, pt 2, p. 30, *et seq.*, Rec. XVII, 101.	...	Sandstones are tremendously developed all along the base of the hills in the various 'dúns' from Hardwar on the Ganges to the Sarda river; and on south-eastwards, in the Sub-Himalayan zone. Those of the Nahun group or eries are the best.
	LALATPUR . .	Gazetteer I, 324 .	COP. GRT I LIM. SLTP TRP.	Sandstone quarries abound in the southern part of the district.
	MIRZAPUR . . .	...	C GRT JD. LIM.	
	Chunar . . .	Gazetteer XIV, pt. 2, p. 54.	...	Chunar stone is famous all over India; and is of unsurpassed excellence in its fineness of grain, compactness, and capability of being quarried in large blocks. It can be carved with extreme delicacy, while large blocks are obtainable for great irrigation works and public
	Kaimur.			
	Mirzapur.			

NORTH-WEST PROVINCES AND OUDH—*continued.*

QUARRY STONES—*continued.*

Mineral or Stone.	Locality.	Reference.	Other Minerals.	REMARKS.
SAND-STONE, *Snd.*—*contd.*	MIRZAPUR—*contd.* Chunar, &c.—*contd.*			buildings. Quarries are numerous at Chunar itself, along the scarp of the Kaimur range, and at Mirzapur, where there is a large and flourishing trade. The usual colours are pale buff; but a rose-coloured variety is common, and greenish beds are met with.
	MUTTRA— Barsana . . Gobardhan . . Nandgaon . .	Gazetteer VIII, 55	LIM. . .	Sandstone fit for building purposes.
SLATE, *Slt.*	DEHRA DUN— . .	...	C. GYP SND LIM. PHO.	
(Includes flags, though these are cleaved like slates.)	Massuri . . .	...	...	Inferior clay-slates, and shales.
	GARHWAL— . . Lobha	Gazetteer X, 296	ASB. C. COP. G. GYP. I. LD. LIM PLM SOP SND. SUL.	Thin dark-blue slate of inferior quality.
	KUMAUN . . .	Rec. II, 89; III, 43; IV, 21; Gazetteer X, 296.	ALM. ARS. C. COP. GRT. GYP. I LD LIM. OIL. PLM. SND. SUL.	No true slate like that of Wales; mainly clay-slates of inferior quality giving coarse flags. Occasionally gneissose schists, giving flags.
	Bora Rao Patti	...	...	Inferior clay-slate.
	Chiteli . . .	Rec. III, 43 .	...	The best slate locality, near Dwarahat. Split along the stratification planes, not along cleavage planes as is the way with true slates. Good enough for roofing purposes: supply very large.

NORTH-WEST PROVINCES AND OUDH—*continued.*

QUARRY STONES—*concluded.*

Mineral or Stone.	Locality.	Reference.	Other Minerals.	REMARKS.
SLATE, *Slt.* —*contd.*	KUMAUN—*contd.* Dhari . . .	...	...	Inferior clay-slate.
	Naini Tal . .	...	...	Ditto ditto.
	Ramgunga R. . .	..	..	Two quarries on the banks of this river in the Sult-patti. Clay-slate.
	LALATPUR— Girar . .		COP. GRT I. LIM SND TRP.	The Bijawar series occurs to the south-west of this village, in which some clay-slates or shaly flags of inferior quality may be found.
	BANDA— Banda . . .	Mem II, 76 .		Dyke of pure horn-blendic rock.
TRAP, &c., *Trp* (Includes basalt, whinstone, and other compact massive dark coloured rocks of volcanic origin.)	JHANSI— . . . Betwa R.	Gazetteer I, 261 .	GRT LIM. SOP.	Trap, or greenstone dykes are to be met with in the valley and in the southern part of the district.
	LALATPUR— . . Birdha.	...	COP. GRT I. LIM SLTE. SND.	An outlier of the Deccan trap near this place.
	Mauraura . .	...	...	A larger outlier of the Deccan trap south-west of this place.

GEOLOGICAL SURVEY OF INDIA DEPARTMENT.

TRI-MONTHLY NOTES.

4. ENDING 31ST JULY 1890.

Director's Office, Calcutta, 31st July 1890.

The staff of the Survey is at present disposed in the following parties:—

Madras Party.—R. B. FOOTE, F.G.S., Senior Superintendent, Bellary District.

Burma Party.—THEO. W. HUGHES HUGHES, A.R.S.M., Superintendent.
TOM D. LATOUCHE, B.A., 2nd Grade Deputy Superintendent.
FRITZ NOETLING, Ph.D., Palæontologist.

Baluchistan Party.—R. D. OLDHAM, A.R.S.M., 1st Grade Deputy Superintendent.
Sub-Assistant Kishen Singh.
Sub-Assistant Hira Lal.

Hazara Party.—C. S. MIDDLEMISS, B.A., 2nd Grade Deputy Superintendent.

Darjiling and Sikkim.—P. N. BOSE, B.Sc., 2nd Grade Deputy Superintendent.

Head Quarters, Calcutta.—C. L. GRIESBACH, C.I.E., Superintendent.
P. LAKE, B.A., Asssistant Superintendent.
P. N. DATTA, B.Sc., Assistant Superintendent.

The Director returned from tour on the 18th May. At Lahore, it was ascertained from the Director, North-Western Railway, that the working and out-put of coal at the Dandot colliery were decidedly improving; so that there was no necessity to make further geological investigations in that connection.

Proceeding to Baluchistan: the sites selected for oil-boring in the neighbourhood of Spintangi by Mr. Oldham were approved. The survey for coal in the Bolan Valley was being carried on. Here, it was ascertained that a seam of more improved quality and lie occurs in the neighbourhood of the Bohr hill, giving a total of 2'-9" of coal and 1'-1" of partings, which seems to be sufficiently extensive and close enough to the railway to justify systematic working. A visit was then paid, at the suggestion of the Director, North-Western Railway. to Laki in Sind, where there is a warm sulphur spring, but without finding any trace of oil shows, as had been hoped might exist.

The oil development near Rawal Pindi, and the coal occurrence near Abbottabad, were then enquired into. The disappointment in the oil exploitation so far, may be attributable to the boring at Fateh Jung having been run down, on what is considered the oil-bearing band, too near to, and on the wrong side of, its outcrop. Unfortunately the period of the lease is running out fast; and the exploring party had to move to another part of the Punjab, where there appears more chance of striking flowing oil within the time at their disposal.

The coal outcrops in Hazara, so far as they have been tried by private working, and by the Department of Public Works, are very poor and badly situated within a complicated and much fractured part of the Dore valley. Many other outcrops are talked of in that tract of country; and it was decided that Mr. Middlemiss should make a thorough survey of the conditions of the coal.

At the earnest request of the Engineer-in-Chief, Frontier State Railways, Mooltan,

the proposed sites for bridging the Indus were visited, with a view to forming an approximate idea of the conditions of the river bed at these places.

In communication with the Consulting Engineer to Government of India for Railways, at Nagpur, reporting better coal from the Eeb river bridge excavations on the Bengal-Nagpur Railway, the return to head-quarters was diverted in that direction. The coal was found to be not much better in quality than that already known in the field; but it is at least 8 feet thick and of uniform quality in the excavation, which is sufficient to warrant systematic boring, provided the seam is found to continue as good to the deep, in a boring the site of which was selected on the right bank of the river.

The Salt-range party having been broken up at the end of the field season, Mr. C. S. Middlemiss was moved to Hazara for coal exploration near Abbottabad; Mr. Datta returning to head-quarters at Calcutta.

Mr. T. W. H. Hughes returned to head-quarters, and availed himself of special leave for six months.

Mr. LaTouche returned to head-quarters and availed himself of privilege leave for three months.

List of Reports and Papers sent in to office for publication or record during May, June, and July 1890

Author.	Subject	Disposal
J. R. Royle, C.I.E., India Office, London.	Memorandum on Indian Steatite	Published in the "Records of the Geological Survey of India," Vol. XXIII, part 3
R. B. Foote .	Contribution to Provisional Index of important minerals, &c., Madras Presidency	Published in the "Records of the Geological Survey of India," Vol. XXIII, part 3
"	Translation from the German of a "Report of a journey through India in the winter of 1888-89 by Dr. Johannes Walther."	Ditto ditto
C. L. Griesbach, C.I.E. .	Geology of the Central Himalayas	Will be published as "Memoirs of the Geological Survey of India," Vol. XXIII
R. D. Oldham . . .	Report on the geological examination of the Bolan Pass	Recorded
T. H. D. LaTouche . .	Report on the Coal-fields of Lairungao, Maosandram and Maobelarkar in the Khasi Hills.	Published in the "Records of the Geological Survey of India," Vol. XXIII, part 3
C. S. Middlemiss . .	Geological sketch of Naini Tal .	Will be published in the "Records of the Geological Survey of India," Vol. XXIII part 4
P. Lake	On the Laterite of the West Coast	Will be published as "Memoirs of the Geological Survey of India," Vol. XXIV, part 3.
Prof. W. Waagen, Prague	Description of the Salt Range Fossils.	Will be published as "Pal. Indica," Series XIII, Vol. IV, part 2.

List of Assays and Examinations made in the Laboratory, Geological Survey of India, during the months of May, June, and July, 1890.

Substance.	For whom.	Result.									
4 Samples of coal, from Twindaw, Kyet-so-bin, Kodaung, and Let-ko-bin.	F. Herrmann, Rangoon.										
Copper ore (chiefly copper pyrites) from Chunabati, Jalpaiguri.	E. E. Lewis, C. S., Commissioner, Rajshahye Division.	Hygroscopic moisture 1·03% Copper (Cu) 5·62%									
8 Samples of coal, from the bed of the Eeb River (Raigarh-Hingir coal-field).	Dr. W. King, Director Geological Survey of India.		1	2	3	4	5	6	7	8	Average of 8 coals.
		Moisture	3·56	2·16	3·44	1·80	1·88	2·40	2·52	2·76	2·57
		Volatile matter	23·64	21·08	25·36	23·94	19·92	22·20	24·48	22·92	22·94
		Fixed carbon	48·74	41·48	47·60	40·76	34·40	38·96	50·80	47·76	43·81
		Ash	24·06	35·28	23·60	33·50	43·80	36·44	22·20	26·56	30·68
			100·00	100·00	100·00	100·00	100·00	100·02	100·00	100·00	100·00
			Cakes, but not strongly. Ash—dark reddish brown.								
		Calorific power in heat units (C)	..	...	6,600	...	...	...	6,790	...	...
		Evaporative power	...	...	12·2	...	...	...	12·6	...	...
Coal from Kodaung, for distillation.	F. Herrmann, Rangoon.										

5 Samples of limestone from Upper Burma, between Kalewa and Kyeigone.	H. Groves, Executive Engineer, Chindwin District.	See analyses below.

	Compact Limestone.		Loose Travertine.		
	Indingyi.	Koortha.	Kyuwa.	Wo-Yen.	Label defaced.
	1	2	3	4	5
Organic matter	...	...	2·23	1·74	·98
Insoluble	·36	·21	17·40	11·03	7·94
Alumina and oxide of iron	·16	·06	1·91	2·24	1·19
Carbonate of lime and magnesia (by difference)	99·48	99·73	78·46	84·99	89·89
	100·00	100·00	100·00	100 00	100·00

Shale from Kalabagh	P. N. Datta Geological Survey of India.	Distilled—yielded a small amount of yellow-coloured oil.
4 Specimens of minerals, said to be from Hazaribagh, for determination.	R. W. Bachrach.	
4 Specimens of building stone, quarried in Western Rajputana, for determination.	The Resident, Western Rajputana.	No. 1 Aboo stone = Argillaceous schist or phyllite. „ 2 „ = Felspathic gneiss. „ 3 „ = Argillaceous schist. „ 4 Palrec stone = Micaceous quartzite—laminated.
Coal, from Warora, taken from the full tender of an engine just about to take a train, for comparison with the coal from the bed of the Eeb River.	R. T. Mallet, Consulting Engineer to the Government of India.	See analysis below.

	Average taken from 23lb of the coal.	Carbonaceous shale, picked from the 23lb of coal.
Moisture	9 00	4·56
Volatile matter	24·60	18 66
Fixed carbon	37·76	21·24
Ash	28 64	55 54
	100·00	100·00
	Does not cake. Ash—light grey.	Does not cake. Ash—light grey.
Calorific power in heat units (C)	5319	...
Evaporative power	9·9	...

List of Assays and Examinations made in the Laboratory, Geological Survey of India, during the months of May, June, and July, 1890—continued.

Substance	For whom	Result.
5 Samples of coal, from Lwindaw, Kyetsobin Letkobin, Letkobin No 2, and Kotaung, Upper Burmah	GILLANDERS ARBUTHNOT, & Co Calcutta	
Coal, from the Sarakula Valley, 8½ miles from Quetta, on the Quetta-Gandak-Kach Road, highest pit 70′ below the surface.	HIRA LAL, Geological Survey of India	Moisture . . . 6 16 Volatile matter . . . 37 86 Fixed carbon . . . 54 68 Ash . . . 1 30 100 00 Cakes strongly Ash—reddish brown Calorific power in heat units (C) . . . 8800 Evaporative power . . . 16 3
Limestone from Kyouk-phyu-doung Hill, near rest-camp of same name on Kanhaka road, 9 miles from Kan Chin Lushai Mily Ex Force	H. GROVES, Executive Engineer, Chindwin Division	Insoluble in HCl. . . . 4 89 Oxide of iron and alumina . . . 83 Carbonate of lime (by difference) . . . 94 28 TOTAL 100·00
Specimens from Darjiling	P. N. BOSE Geological Survey of India	Highly compressed carbonaceous shale occurring in the Dalings fringing the coal field. Moisture 1 24 Volatile matter 4 18 Fixed carbon 5 20 Ash . 89 38 TOTAL 100 00 Does not cake Ash—brownish red Earthy hematite, occurring in the Dalings fringing the Coal field Contains 3 86% of oxide of iron = 2 7% iron.

Limestone from Darjiling.	P. N. Bose, Geological Survey of India.	SiO_2 + insoluble . . . 53·10 Fe_2O_3, Al_2O_3 . . . 2·45 CaO . . . 23·77 MgO . . . ·70 CO_2 . . . 18·65 H_2O . . . ·58 TOTAL . 99·25
4 Samples of coal	The Bengal Coal Company, Limited, Calcutta.	
2 Samples of quartz, for gold.	F. C. Lethorn, Calcutta.	
2 Samples of quartz, for gold.	W. T. Considine, Calcutta.	
3 Samples of coal, from Kyetsobin No. 2, Letkobin No. 2, and Chadauk.	F. Herrmann, Rangoon.	
Coal from Kyetsobin No. 2, and Chadauk, for distillation.	Ditto.	
A sample of galena	R. W. Bachrach, Calcutta.	
Copper ore from Manbhoom, chiefly malachite with quartz, and schist.	Jardine, Skinner & Co, Calcutta.	
Washed and unwashed alluvial soil, samples A. and B. for gold.	Mackillican & Co. Calcutta.	
Lignite from Chittagong	D. R. Lyall, C. S., Commissioner, Chittagong Division.	Moisture . . . 20·20 Volatile matter . . . 31·70 Fixed Carbon . . . 14·80 Ash . . . 33·30 TOTAL . 100·00 Does not cake Ash—red.
4 Samples of quartz, for gold	Mackillican & Co., Calcutta.	

List of Assays and Examinations made in the Laboratory, Geological Survey of India, during the months of May, June, and July, 1890—concluded.

Substance.	For whom.	Results.
2 Samples of alluvial soil, and 2 of quartz, for gold.	MACKILLICAN & Co., Calcutta	
Manganese ore, from 2 miles south of Kanevihalli	R BRUCE FOOTE, Geological Survey of India.	Insoluble + SiO_2 . . . . . . 38·96 Fe_2O_3 + Al_2O_3 . . . . . . 12·82 MnO_2 . . . . 42·90 CaO . . . . ·78 H_2O Combined . . . . . . 3·16 H_2O Hygroscopic . . . . . ·67 99·29
2 samples of minerals for determination.	J. M. STONEY	
Galena	R. W. BACHRACH, Calcutta .	

Notifications by the Government of India during the months of May, June, and July, 1890, published in the "Gazette of India," Part I.—Appointment, Confirmation, Promotion, and Retirement.

Department.	No. of order and date.	Name of Officer.	From	To	Nature of Appointment, &c.	With effect from	Remarks.
Revenue and Agricultural.	$\frac{538}{93-13}$S, dated 1st July 1890.	R. D. Oldham	1st grade Deputy Superintendent.	Offg. Supt.	Temporary.	23rd May 1890.	

Notifications by the Government of India during the months of May, June, and July, 1890, published in the "Gazette of India," Part I.—Leave.

Department.	No. of order and date.	Name of Officer.	Nature of Leave.	With effect from.	Date of Return.	Remarks.
Revenue and Agricultural Department.	$\frac{95}{93-8}$S, dated 25th April 1890.	Theo. W. H. Hughes	Special leave.	23rd May 1890.		
Ditto .	$\frac{470}{93-12}$S, dated 20th June 1890.	T. H. D. LaTouche .	Privilege leave.	2nd July 1890.		

Annual Increments to Graded Officers, sanctioned by the Government of India during May, June, and July, 1890.

Name of Officer.	From	To	With effect from	No. and date of sanction.	Remarks.
R. D. Oldham .	R 750	R 800	1st May 1890	R. and A. Dept., No. $\frac{535}{109-4}$S, dated 1st July 1890.	
P. N. Bose . .	660	700	1st April 1890	R. and A. Dept., No. $\frac{413}{109-2}$S. dated 12th June 1890.	

Postal and Telegraphic Addresses of Officers.

Name of Officer.	Postal Address.	Nearest Telegraph Office.
R. Bruce Foote	Yercaud	Salem
T. W. H Hughes	On leave	
C. L. Griesbach	Calcutta	Park Street, Calcutta.
R. D. Oldham	Quetta (Baluchistan)	Quetta.
P. N. Bose	Lhasa Villa, Darjiling	Darjiling.
T H D. LaTouche	On leave	
C. S. Middlemiss	Abbottabad	Abbottabad.
P. Lake	Calcutta	Park Street Calcutta
P. N. Datta	Do.	Ditto
F Noetling	Manda'ay	Man 'alay.
Kissen Singh	Mandra	Rawal Pindi
Hira Lall	Calcutta	Park Street, Calcutta.

ADDITIONS TO THE MUSEUM.

FROM 1ST APRIL TO 30TH JUNE 1890.

Three specimens of nodular concretions from wave-worn hard sandstone rocks, East Coast, Great Cocos Island.

PRESENTED BY DR. A. W. ALCOCK, MARINE SURVEY DEPARTMENT.

Cerargyrite in quartz, from Santa Gertrude's Mine, Pachnec, State of Hidalgo, Mexico.

PRESENTED BY O L. FRASER, INDIAN MUSEUM.

Specimen of auriferous sand and washed gold, from the Sonapet Valley, Chota Nagpur.

PRESENTED BY DR. F. NOETLING, GEOLOGICAL SURVEY OF INDIA.

Eleven specimens of Rubellite, from the Jasper mines, Shan States, Upper Burma.

PRESENTED BY F. MCBLAINE, SECRETARY TO THE FINANCIAL COMMISSIONER, BURMA.

Specimens of mica, from Hazaribagh, Hills north of Patiala, and Madras.

PRESENTED BY H W. NEWTON.

Ingot tin, from Pulo Brunei Smelting Works, Singapore.

PRESENTED BY T. W. H. HUGHES, GEOLOGICAL SURVEY OF INDIA.

Alum crystals, manufactured at Kalabagh, Salt Range, Punjab.

PRESENTED BY P. N. DATTA, GEOLOGIGAL SURVEY OF INDIA.

A sample of native copper, from Zanskar, Kashmir.

PRESENTED BY TOM D. LATOUCHE, GEOLOGICAL SURVEY OF INDIA.

ADDITIONS TO THE LIBRARY

FROM 1ST APRIL TO 30TH JUNE 1890.

Titles of Books. *Donors.*

BALL, *Valentine.*—Travels in India by Jean Baptiste Tavernier, Ba[illegible] of Aubonne. Translated from the original French edition of 1676, with a biographical sketch of the author, notes, appendices, &c., Vols. I-II. 8° London, 1889.

BRONN'S Klassen und Ordnungen des Thier-Reichs. Band VI, Abth. III, Reptilien, lief. 67-68; Band VI, Abth. IV, Vögel, lief. 28-34. 8° Leipzig, 1890.

FEISTMANTEL, *Ottokar.*—Uebersichtliche Darstellung der Geologiscn-Palaeontologischen Verhältnisse Süd-Afrikas. Theil I. 4° Prag, 1889.

THE AUTHOR.

FRITSCH, *Dr. Ant.*—Fauna der Gaskohle und der Kalksteine der Permformation Böhmens. Band II, heft 4. 4° Prag 1889.

HEILPRIN, *Angelo.*—The Bermuda Islands: a contribution to the physical history and zoology of the Somers Archipelago. With an examination of the structure of coral reefs. 8° Philadelphia, 1889.

HIORNS, *Arthur H.*—Iron and Steel Manufacture. 8° London, 1889.

MARCOU, *Jules.*—Jura, Neocomian and Chalk of Arkansas. 8° Pam. Cambridge, Mass. 1889. THE AUTHOR.

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MARCOU, *Jules.*—Les Géologues et la Géologie du Jura jusqu' en 1870. 8° Pam. Lons-le-Saunier, 1889. THE AUTHOR.

" The Mesozoic series of New Mexico. 8° Pam Cambridge, Mass. 1889. THE AUTHOR.

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SHUFELDT, *R. W.*—Remarks upon extinct Mammals of United States 8° Pam. Chicago, 1889. THE AUTHOR.

STEINMANN, *Gustav*, and DÖDERLEIN, *Ludwig.*—Elemente der Paläontologie Hälfte II. 8° Leipzig, 1890. THE AUTHORS.

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EDITORIAL COMMISSION, N. N. ATLANTIC EXPEDITION.

TRYON, *George W.*—Manual of Conchology. Continued by H. A. Pilsbry. Vol. XI, pts. 4 and 4*a*, and 2nd series, Vol. V, pt. 4. 8° Philadelphia, 1890.

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„ Cyclone Memoirs. Part II. 8° Calcutta, 1890. METEOROLOGICAL REPORTER TO GOVERNMENT OF INDIA.

„ List of Civil Officers holding gazetted appointments under the Government of India in the Home, Legislative, Foreign, and Revenue and Agricultural Departments, corrected to 1st January 1890. 8° Calcutta, 1890. HOME DEPARTMENT.

„ List of Officers in the Survey Departments corrected to 1st January 1890. 8° Calcutta, 1890. REVENUE AND AGRICULTURAL DEPARTMENT.

„ Quarterly Indian Army List. New series, No. 3. 8° Calcutta, 1890. GOVERNMENT OF INDIA.

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„ American Journal of Philology. Vol. X, Nos. 2-3. 8° Baltimore, 1889. JOHNS HOPKINS UNIVERSITY.

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BALTIMORE.—Johns Hopkins University Studies in Historical and Political Science. Series VII, Nos. 10-12. 8° Baltimore, 1889.
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" Studies from the Biological Laboratory. Vol. IV, No. 5. 8° Baltimore, 1889. JOHNS HOPKINS UNIVERSITY.

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BRUSSELS.—Bulletin de la Société Royale Belge de Géographie. Année XIII, No 6, and XIV, No. 1. 8° Bruxelles, 1889-1890 THE SOCIETY.

BUDAPEST.—Természetrajzi Füzetek. Vol. XII, No. 4 8° Budapest, 1890.
NATIONAL MUSEUM, HUNGARY.

BUENOS AIRES.—Anales del Museo Nacional de Buenos Aires. Tomo III, No. 16. 4° Buenos Aires, 1890.

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" Journal of the Asiatic Society of Bengal New series, Vol. LVII, pt. II, No. 5; Vol. LIX, pt. I, Nos 1-2, pt. II, No. 1, and Supplement No 1. 8° Calcutta, 1890. THE SOCIETY.

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CAMBRIDGE, MASS.—Bulletin of the Museum of Comparative Zoology. Vol. XVI, Nos. 7-8, and XIX, Nos. 1-3. 8° Cambridge, Mass., 1890.
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„ Oversigt over det Kongelige Danske Videnskabernes Selskabs. No. 3 (1889), and No. 1 (1890). 8° Copenhagen, 1889-1890.
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DEHRA DUN.—Trigonometrical Branch, Survey of India. Spirit-levelled heights, No. 5, Madras Presidency. Season 1888-89. 8° Dehra Dun, 1890.
SURVEY OF INDIA DEPARTMENT.

DIJON.—Mémoires de l' Académie des Sciences, Arts, et Belles Lettres de Dijon. 4^me^ série, Tome I. 8° Dijon, 1889. THE ACADEMY.

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„ Transactions of the Royal Scottish Society of Arts. Vol. XII, pt. 3. 8° Edinburgh, 1889. THE SOCIETY.

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„ Journal of the Society of Arts. Vol. XXXVIII, Nos. 1947 to 1957. 8° London, 1890. THE SOCIETY.

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„ Proceedings of the Royal Institution of Great Britain. Vol. XII, No. 83. With list of members for 1889. 8° London, 1889. THE INSTITUTION.

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MONTREAL.—Annual report of the Geological and Natural History Survey of Canada. New series, Vol. III, pts. 1-2, and maps. 8° Montreal, 1889.
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NEWCASTLE-ON-TYNE.—Transactions of the North of England Institute of Mining and Mechanical Engineers. Vol. XXXVIII, pts. 4-5. 8° Newcastle-on-Tyne, 1890. THE INSTITUTE.

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„ Compte Rendu des Séances de la Société de Géographie. Nos. 5-10. 8° Paris, 1890. THE SOCIETY.

„ Bulletin de la Société Géologique de France. 3^{me} série, Tome XVI, No. 11; XVII, No. 9; and XVIII, No. 1. 8° Paris, 1889-1890.
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„ Mémoires de la Société Academique Indo-Chinoise de France. Tome I. 4° Paris, 1879. SOCIÉTÉ ACADÉMIQUE INDO-CHINOISE.

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PARIS.—Mémoires pour servir à l'explication de la carte géologique détaillée de la France. L'Ardenne, par J. Gosselet. 4° Paris, 1888.
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„ Proceedings of the Academy of Natural Sciences. Part III, 1889. 8° Philadelphia, 1890. THE ACADEMY.

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RECORDS

ERRATA.

MOIRS OF THE GEOLOGICAL SURVEY OF INDIA, VOL XXIV, PART 2.

age 12, 12th line from top, *for* Adatoda *read* Adhatoda
" " 21st " " " " is *read* are.
" 14, in the marginal section, *for* Nahaa Sandstone *read* Nahan Sandstone.
" 29, 8th line from top, *for* canno *read* cannot.
" 138, 4th line " bottom, *for* quantiuve *read* quantitative
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" IV of Index, *for* Read *read* Reade

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as well as takes away all scope for the fossil-hunter, and all that vi... interest which centres round the petrified remains of an earlier life on the earth: w cannot speak familiarly of a "Carboniferous limestone," nor of "Silurian slates," neither can we wander forth with hammer and chisel to any well-known locality whence a harvest of palæontological specimens may be gathered.

No mineral wealth.

Besides this, there are no mines of economical wealth to be disclosed. There is neither gold in the streams, nor copper nor lead in the limestone: there is a dearth of useful minerals, with a trifling exception, as there is a dearth of fossils.

At first sight, then, it is difficult to imagine what the geologist can find to say of a district so barren and unfruitful: and I must caution the reader at the outset that here will be found no idyllic geological romance. If he wishes to know what is concealed beneath the bright verdure of young mountain grass, dotted with the sombre oak, rhododendron, and cypress, he must sit down to a mental exercise such as chess or a mathematical problem.

General objects of the paper defined.

Nearly every visitor to Naini Tal knows that, roughly speaking, there is a difference between the rock forming each side of the lake; that there is limestone on the rugged Ayarpata side and slate (locally called shale) on the gently sloping Government

House side. A little more inquiry would teach him that this broad distinction is not everywhere carried out. A certain amount of slate will be found associated with the limestone on the south-west side, whilst a few outlying patches of limestone will be found covering the slate on the north-east side. Without going into details here as to certain other variations which occur, I may briefly state that there is a definite geological pattern, more or less concealed at the surface, set out before us as our study, the salient points of which are represented in the geological map of the settlement. It is this pattern—this inlaid-work of different rocks—that we must understand, and if the reader has the patience to accompany me in a few rambles over these hills with other objects than picnicking, I hope at the conclusion to make him as familiar with the mechanism of the earth's crust here, as a watch-maker is familiar with that of a time-piece. He will be able to see faulted boundaries and natural boundaries as clearly portrayed on the surface of the earth as if the hill-sides themselves were painted different colours, and thus he will find that the chaotic rock pattern of the hills is not accidental, but has a real meaning in the growth and development of the mountain area.

In this country, where the lamp of pure science burns feebly, or not at all, there are perhaps but few who on coming to Naini Tal are able to look upon the landscape with a geological eye, but few who see in the surrounding hills and valleys any harmony of composition and structure other than that of a pictorial kind. For the rest, Deopata is one peak and Ayarpata another, whilst the different glens, valleys, and tarns are each themselves and nothing more. All latent bonds of structure and origin, all the hidden processes of constant change that are ever altering the face of the scene, are, I am afraid, as unnoticed to-day as if Sir Charles Lyell had never lived or written his "Principles of Geology." I hope in the following sketch to draw some little attention to this fairly interesting theme: perchance here and there may be found some few disciples of this last-born of the sciences for whom the matter may not be unpalatable.

Coming to the practical question as to what geology has to say regarding the safety and permanence of the station and its communications, I hope to be better understood; though on such a subject one is necessarily tongue-tied to a considerable extent. Ever since the disastrous landslips of 1880, the Naini Tal public has been somewhat agitated as to the probability of further landslips, whilst considerable confusion has been introduced into the subject by small slips having occurred now on this side, and now on that side of the lake, and apparently of slate and limestone irrespectively. Now it would not do for me to blacken a house-holder's prospects by proscribing as dangerous any particular site in Naini Tal. However much I might be able to do so, I should bring a shower of abuse upon myself were I to colour a map of the station shewing all the dangerous localities. And yet there would be very little difficulty in so doing. It is merely a problem involving a few factors such as composition of the rock, its whole or shattered condition, the angle of the hill slope, the angle of dip or cleavage, and the relations these four factors hold to one another.

Nevertheless, I shall later on point out broadly the difference between a safe slope and a dangerous slope; and give a few general principles whereby each resident may be able to see for himself whether his site is safe or not.

GEOLOGY.

Section from Kathgodam to Naini Tal.

Bhábar deposits.

In addressing myself to the geology of Naini Tal—the foundations of the subject so to speak—I think it will be well to describe actual excursions along definite directions in and around Naini Tal. We will begin therefore, as all must who come to this summer resort, with the line of country between Kathgodam, the terminus of the Rohilkund and Kumaon Railway, and Naini Tal. Even before reaching Kathgodam there is much to be learnt regarding the features of the country. We may know by the peculiar labouring of the railway carriages that we are not crossing what looks like a vast plain, but are really ascending an incline of about 50 feet a mile, which is abruptly terminated as we can see from the carriage windows by the long blue and purple line of the Himalaya rising sheer and steeply out of it. This incline, over which the line runs, is known as the Bhábar. It is a very gently sloping deposit of gravels, with occasional sand and clay beds, the outpouring during recent times of the various rivers and streams which drain southwards from the Himalayan range. Year by year as the annual monsoon bursts upon the steep slopes of the hills, more and more detrital material is carried down by the uniting of rills, torrents, streams and rivers, and is deposited at the foot of the hills when the speed of the streams and rivers is slackened by the gentle slope of the country. Perhaps nowhere in the world can we get a better insight into the processes by which geological strata are accumulated than along the mountain-foot of the Himalaya. This elevated belt of Bhábar gravels which girdles the whole length of the southern foot of the Himalaya is the great spoil-bank, the result of the disintegration of the mountains by water action. As we get a nearer view of these mountains, we see great rifts in their sides, that is to say, the gorges and ravines, whence the excavations have been made by the water to supply the gravels of this Bhábar zone. Having once realised this aspect of change and instability in the geological features before us, and seen how the Bhábar zone is enriched with material at the expense of the Himalaya, we shall be in a position to understand what a powerful agent of change denudation is in this elevated mountainous tract subject to about 100 inches of rainfall every year.

But in most cases this denudation, except when viewed in this large way, is almost invisible to us. Nearly all the glens whose mouths open towards the plains are covered densely with a forest of Sál and other trees. Only very seldom do bare hill-sides scored by rainfall and torrents meet our view. One such case is, however, very noticeable, a little east of Kathgodam as we begin the journey up to Naini Tal. A very rapid weathering of the edges of the strata is there taking place so that vegetation can keep no hold on the slope, and undergrowth and forest alike have had to fall. At the base of this wound in the face of the hill, we may see a yearly accumulating detrital fan, which, in a semi-liquid condition, moves during the rains like a glacier over the flatter country to the south, and is a source of much damage to the canals in the vicinity. Other places near Naini Tal where the individual processes of denudation can be studied, especially during the monsoon, will be mentioned in their place in this paper. I here wish merely to draw attention to the fact that immense denudation of these Sub-Himalaya takes place, as evinced by the

Bhábar deposits and their ever-changing conditions, without, save in rare cases, leaving palpable traces behind them on the parent hills, whose rounded forms, covered with luxuriant forest, undoubtedly at first sight suggest that rest, strength, and fixity proverbially, but erroneously ascribed to all mountains.

It is certainly the case that very much more erosion takes place in these Sub-Himalaya, than in the outer Himalaya, and still more than takes place in the regions of perpetual snow, but the impression on any one visiting these parts is the very reverse. Bare precipices and jagged rock are the rule of course, when the limit of vegetation is passed at about 12,000 feet above the sea, while day and night from different causes the hill-sides resound with the crash of falling blocks as they crumble from tottering pinnacles or charge down the terminal moraine of a melting glacier. This antagonism of impression and fact is not introduced here as a paradox, but rather as an illustration of the magnitude and importance of those generally noiseless and invisible forces—denudation by water action—as compared with the more striking phenomena effected by frost and snow.

With these general remarks on the Bhábar deposits, let us turn our attention to the section before us. A noticeable orographical feature of the Sub-Himalyan rocks on which we first tread is the absence of that subsidiary and distinct range of hills, which commonly first breaks the monotony of the plains, namely, the Siwaliks, and which is characteristically displayed south of the Dehra Dun. As we journey from Kathgodam to Naini Tal, we cross no such range of hills running parallel to a still higher range, nor are there any other well-marked surface features distinguishing the younger tertiary rocks from the older slates and limestone of Naini Tál proper. All is welded into one nearly homogeneous range with secondary spurs running out to the plains. This is an unfortunate accident so far as our section is concerned, from an illustrative point of view, and it will therefore be necessary to diverge in imagination from the line of our section in order to understand the typical aspect of the Sub-Himalayan zone.

Sub Himalayan rocks.

Away west, along the edge of the hills, in the neighbourhood of Rámnagar and Kálágarh, we first begin to see a longitudinal subsidiary range to which the name Siwalik may be given geologically though no such name is known to the natives. As soon as this range begins to set in, we see that it is the accompaniment of two younger rock stages of the Sub-Himalayan system, namely, the Upper Siwalik conglomerate and the middle Siwalik sand-rock stages. As I have written fully on this subject in a memoir just published,[1] I shall only make a passing reference to it here, in order to bring out the connection between the present Bhábar deposits and the older Sub-Himalayan deposits of our section.

The meaning of the word Siwálik—the track of Siva, the destroyer—shews that even by the natives of this country in a former age the aspect of disturbance and contortion visible in the rocks of that range had been vividly apprehended. And this is the first aspect it is necessary to notice here, for in this respect, and in this only, does its geological structure differ from that of the Bhabar zone. At a comparatively late geological time, but before man's appearance on the earth, the Siwalik conglomerate lay flat and undisturbed at the foot of a Himalayan land almost precisely the same

[1] Memoirs G. S. of I., Vol XXIV, pt. 2

in its general features as that which now exists. The Siwalik conglomerate was then in fact the Bhábar deposits of its day; since which time it has been elevated and marked off from a newer Bhábar that at once began to form, and has acquired those corrugations of its strata in lines parallel to the higher hills, which by superstition were credited to the action of Siva, and by science are recognised as due to the lateral crumpling of the earth's crust.

The Nahan sandstone.

But the section before us, between Kathgodam and Naini Tal, is devoid of these two rock stages of the Sub-Himalaya. The whole of the labyrinthine tract of Sál-covered hills, between the Bhábar zone and the neighbourhood of Douglas Dale, is composed of the lowest member of the Siwalik series, namely, the Nahan sandstone. It takes its name from the town of Nahan, where our pioneer of systematic geological work in the Himalaya, Mr. Medlicott, first described it; and when once seen, in its full thickness of several thousand feet, its massiveness, its freedom from local variations, and its general character as a rather soft but eminently workable micaceous sandstone, of ochre or greenish-brown tints, there is no possibility of mistaking it, not only from one end of the Himalaya to the other, which is no mean distance, but even further, as it circles round about our north-west frontier on the one hand, or Burma on the other.

Notwithstanding its great thickness, and the majestic fold bent back upon itself into which it is thrown, as illustrated in section I, I have shewn elsewhere in my memoir that its apparent oneness with the greater Himalaya is misleading. Though now as much a part of the Naini Tal range (geographically) as it is possible to conceive, it is really but a comparatively modern addition to the Himalaya as a whole. To be clear in our conception of it we must regard it as once having lain flat and monotonous, as the country around Bareilly, at the foot of a Himalayan range not very different in its main features from what we now see; and as having then been hardened by age and superincumbent strata, and synchronously upheaved and welded to form but one piece with the range of older hills.

Thus just as the Siwalik conglomerate found west of our section is but an ancient Bhábar country that has been upheaved folded and incorporated with the parent Himalaya to the north, so the Nahan sandstone and shales are but a still more ancient Tarai country that has suffered in a like manner save that its incorporation is more complete and assured.

Our first excursion therefore, whether by tonga road or by bridle path, takes us inevitably across this Nahan zone, the history of which I have briefly summed up. For more complete information I refer the reader to my memoir.

The main-boundary fault.

At Joli Kot, a little south of Douglas dale, where the cart-road after a divergence up the Nalena R., emerges to a full view of the white houses of Naini Tal, the Nahan zone is left behind. In a moment we cross the great master-fault of the south edge of the Himalaya, called the main-boundary fault, which divides these Nahans from the older rocks; but the actual line of this hiatus in the geological structure of the country is not marked by any prominent surface feature. This line is one that can only be found with great care and patience, and we must not expect the moss-covered rocks in the cuttings to tell their tale uninvited; for indeed a very practised eye and hand are requisite to determine where the Nahan rocks end, and the older Himalayan rocks begin.

Trap.

For a considerable distance, the rock north of the main-boundary is a very much decomposed trap, is decomposed on the surface of the road as to greatly resemble the Nahan sandstone.[1] Nothing but a specimen dug from the very heart of the cuttings and subjected to microscopical examination will fully reveal that we have crossed the rubicon and that we are now on Himalayan as distinguished from Sub-Himalayan formations.

Limestone and slates.

For a little over a mile this trap continues, and we then enter on the purple, grey, and sometimes carbonaceous slates, which, with the superincumbent dark blue-grey limestone, occupy so much of the nearer ranges in this and other parts of the Himalaya, and here too the mystery of these azoic formations must begin to strike us. Not a trace of a fossil has ever been found in them. Were we in Wales, or some of the western counties of England, we could well imagine these slates, grits, and calcareous bands to contain trilolites, graptolites, or mollusca, such as are so familiar there in the great Silurian and Cambrian systems. And as for the massive limestone, we should certainly be tempted to regard it as the mountain-limestone of the northern counties and be prepared to find it crowded with marine fossils. In this aspect, then, the contrast between these Himalayan rocks and those in England of a similar composition is very noticeable. There is no room for doubt that both sets of strata were accumulated slowly in a fairly deep sea, at some period in the world's history: indeed geology would be no science at all were it possible to call this conclusion in question. That being so, there are three courses of belief open to us: we may believe that they represent deposits formed before the dawn of life on the earth, or that they were formed under some conditions fatal or distasteful to living beings, or that they once contained these remains and that subsequent slow chemical and mechanical changes in the rock have obliterated all traces of them. Each of these theories is however beset with difficulties, and Himalayan geology has waited long, and must still wait before one or other theory can be adopted with any semblance of truth.

Waiving this somewhat transcendental question, let us see what can be learnt as to the structural history of these formations in the building of the Himalaya. On our line of section up from Joli Kot to the lake there is a general dip of the slates at angles between 25° and 30° (though often varying) in a northerly direction. About ¾ mile south of the outlet of the lake the massive limestone, with some few hard purple grit bands, normally succeeds the slates. It is nevertheless certain that this though true is not the whole truth. At more than one point along the two or three miles occupied by the slates, there must be repetition by reduplication. This is shown by the fact of the recurrence of outliers of the massive limestone at a much lower elevation; and further south than that at the lower end of the lake. The village of Naikana, due west about a mile from Douglas dale, is built on one of these outliers, whilst there is another small one south-east of Manora. Still more west at Balnekhan the same limestone is exposed, and again at Jagueda, south of Khurpa Tal, there is a continuous exposure of the limestone of full thickness and dipping steeply south-south-west. The horizontal section (Section I) will illustrate better than words the folding and faulting that has supervened and brought about the present state of things.

[1] In the accompanying plate, Section I does not cross the trap.

Cleavage in the slates.

We must not forget to notice the true cleavage possessed by these slates. This is liable to be overlooked, and indeed has been overlooked by many observers in the Himalaya, from the fact that it generally coincides with the bedding. The reversed folding and faulting has tended to turn all the individual beds of the slate series so as to dip towards the north, which is the dip of the cleavage in this locality. A little patience will easily reveal the fact that this is not by any means universal; whilst in some of the steeper parts of the Balia ravine, due east of the old Gurkha barracks, fragments of slate may be picked up where the cleavage planes alone are well-developed, the bedding being feebly indicated by different tints of grey. A remarkable condition of the slate all over Naini Tal, and indeed in most parts of the Lower Himalaya, is its utter worthlessness for roofing purposes: there is no durability in it, as may be seen by the way it breaks up and crumbles anywhere near the surface of the ground. This seems to be due in the first place to the fact that it is never very pure; we nearly always see the colour of the rock changing rapidly through various shades of grey, or purple and green, and its texture altering from a smooth, satiny-surfaced slate to an impure irregularly-cleaved rock indicating sandy admixture. Every here and there bands of strong grit or quartzite are interbedded, which have still further tended to prevent the rock from assuming the perfectly parallel folia so desirable for economical purposes. But above all, the decidedly cataclastic nature of the rock is what tells most against it. The cleaving forces that first made the rock into a slate have, in this greatly crushed region of the Himalaya, overdone their work; and the rock besides becoming cleaved has also been sheared, that is to say, the particles of the rock have not only re-arranged themselves parallel to one another to form a slate, but this not having given sufficient relief to the crushing forces, there followed a bodily movement along closely packed planes of shear, and these planes of movement crossing the cleavage have rendered the rock liable to break up into splinters.

So far as I have seen, slates are never used by the hill people for roofing purposes, and they assuredly would be, could they be found to take the place of the thatch or wooden roofs in this very rainy region. In those parts of the Himalaya where the older micaceous schists prevail, we constantly meet with the châlets of the villagers roofed with inch-thick slabs of glistening schist, which circumstance shews that slate would be used for the same purpose could it be found.

The massive limestone south of the lake.

As we ascend the last steep climb towards the lake, we find the massive limestone gradually asserting itself, first in isolated blocks covered with fern and moss, which have slipped down from above, and then in larger, craggy platforms cut up by deep, damp fissures. None of the limestone so far is actually *in situ*, and all of it possesses a tilt downwards in the direction of the hill-slope. On getting near the lower bazar, the massive limestone sets in with more intensity, and associated with it are some thick, dark, purple sandstone bands outcropping from Fairy Hall to Springdale. Much of the latter rock may be noticed built into the retaining walls and pavements as we pass through the bazar. But the limestone is all round us, of a dark indigo colour outside, and a paler blue-grey when freshly broken. It is impossible to overlook it, for directly or indirectly much of the beauty of Naini Tal, and many of its most impressive features, owe themselves to it. In the first place it constitutes the floor of the dam that keeps back the water of the lake; secondly, all the more rugged

peaks and precipices west of the lower bazar may be seen to be constituted of it; whilst lastly, its rough and honey-combed exterior, and the soil and moisture that it forms or attracts, have enticed a luxuriant growth of plants, shrubs and trees to take up their abode on it.

We have now arrived in the cool and shady valley of Naini Tal, amid a keener and lighter air, amid a more temperate flora of fir, oak, and rhododendron, as contrasted with the heavy hot sub-tropical climate of the sál-covered Sub-Himalayan tract; we have gained these time-worn slopes composed of rocks that have a wide distribution all over the outer Himalaya, and we shall now proceed to take a few smaller excursions along such lines in and around the station as will best illustrate our purpose.

Section from the Lower Bazar to Giwalikhet and Ayarpata.

View across the valley.

This line of country is well known to picnickers on their way to the "landslips" as they are called. After passing through the lower bazar, where geological observations are hampered considerably by the usual accompaniments to an Indian native town, and by the noxious smells of the sulphur spring which issues from the rock at the lower end of the lake, we get a good view opposite of the southern spur of Sher-ka-danda as we ascend by the Tarai district office. We see the uniform slopes about Stoneleigh composed of the slate series, with a large number of loose blocks of the massive limestone still clinging to the surface, as remnants of a skin or covering of the limestone that has not yet all been denuded away. Many of these blocks at first suggest the idea that they have at some period come bounding down the hill-side from the larger masses of the same limestone higher up near the crest of the ridge, three of which are very distinctly seen between the highest point of Sher-ka-danda and the Bleak house slip. This appearance is however in a measure deceptive, like a great many others which geology presents to us. These blocks have probably never travelled at any great pace down the hill-slope, but have gradually, inch by inch, worked their way down as the underlying rock became eaten away by weathering.

Swallow holes.

Above the Tarai district office the massive limestone is interbedded with much purple grit with subsidiary slate. At the bend in the road marked 6,627 feet bar. the purer beds of massive limestone are met with again, but they shew no good evidence of dip. The country from this point on to Giwalikhet is very irregular and uneven, full of small hollows, and with hillocks of limestone thrown about as it were in a fantastic manner. These hollows suggest ancient "swallow holes" on a small scale, and recall many of the aspects of the mountain limestone country in England. In the rains the depressions become filled with water which cannot easily escape on account of a superficial soil of tenacious clay, very slippery to the feet, which clothes this part of the hill. At Giwalikhet itself there is a larger wooded hollow also filled in the rains by a small lake. I am inclined to think that it also is of the nature of a "swallow hole," which has had its underground channel filled up by mud and clay to the larger extent.

The landslips.

At the south-west end of this tarn there is a slight rise as we approach the very awe-inspiring precipices which have received the name of the "landslips." Directly beneath our feet we look down

a cliff or scarp descending 1,000 feet, sheer, at an angle of 60° or 65°. Above us in the direction of the 7,468 feet hill we see another 1,000 feet of sheer rock at a somewhat lower angle. We have therefore before us in profile what seems a perpendicular cliff, 2,000 feet high, composed of bare beds of limestone with some interbedded slates and grits dipping about 30° north.

This view down the landslips is very fine in any weather, but more especially in the rains when innumerable rills of water are actively at work tearing down fresh debris from the high naked scarp, and hurling it out of sight far below us through clouds of mist, to eventually repose a heterogeneous assortment of fragments on the low ground at the head of the Nehal N. There it accumulates, and will continue to do so until Ayarpata with its riven sides is no more, or until some change in the drainage causes it to be swept away by torrents more quickly than is the case at present.

Scree material.

This scree material at the base of the scarps is well worth a visit on its own account, if time and space permitted; for there may be seen, in those great gathered heaps, 100 feet or more in thickness, the half-way stage in the forming of a new deposit from the wreck of an older one. It has not been sufficiently sorted and rolled as to its constituents to be left in a horizontal accumulation of gravel and sand, but it lies in any plane on which it happens to fall, clothing the hill-sides in an amorphous mass of angular fragments, and burying completely out of sight all the rock formations which are *in situ* beneath. Of course it is a transitional, and therefore a very unstable formation, and will doubtless never be preserved in the future geological record of this part of the earth. Its ultimate destiny is to be much more sorted and rolled as it is carried further and further down the Nehal line of drainage to the plains. Every step it takes in this direction will tend to select out the coarser and the finer material to make the pebbles more worn and rounded, or to split and wear them down to powder, until finally they lie in very nearly horizontal layers of alternating sands, conglomerates, and clays as a new addition to the Bhábar deposits.

Calcareous tufa and Gypsum.

A small amount of calcareous tufa is forming in and among the scree material, and often lines the water channels, giving a home to a miniature forest of maiden-hair fern in which one may walk ankle deep. Besides calcareous tufa, gypsum in small quantities is also being laid down, sometimes in the lower parts of the precipices themselves, but more often among the scree material. Below the site of the old Nehalpur bridge there are more extensive beds of it which I have described elsewhere.[1]

Ayarpata.

Mounting from the wooded hollow of Giwalikhet by a long-since disused and scarcely distinguishable path, we zig zag our way up to the picnic ground near the top of Ayarpata. On the way we cross a bed of trap apparently insinuated among the bedding, and above it a set of rocks containing a fairly large amount of slate of grey and purple colour, also dark grey grits or quartzites, besides the ordinary massive limestone. At the picnic ground we can see these rocks striking (with a dip of 60°) almost due east towards 6,969 feet bar. But a much better section of these same rocks is to be obtained by returning from the picnic ground along the ridge running south-west to the 7,468

[1] Records G. S. of I., Vol. XXII, p. 137.

feet peak, half a mile south of Ayarpata. The band of trap in particular may be well-studied along its outcrop just north of this peak. It may be seen to be a truly intrusive dyke although apparently so parallel to the bedding; for, near a steep little pinnacle of rock, there is a vein of the dark trap distinctly intruded in the limestone, and brecciating it. In a westerly direction this thin band of trap may be traced with a little difficulty as far as the Khurpa Tal road. It is well exposed on the new mall between the Khurpa Tal road and Ayarpata, where it stands out as a harder mass among the softer slates and limestone. Wherever it is clearly seen it may be noticed to be slightly coarser grained within than at the sides.

Trap.

Returning to the picnic ground, and ascending to the north summit of Ayarpata (7,721 feet), we find the ridge forming this summit to be composed of the limestone beds dipping south instead of north, that is to say, we have crossed a synclinal (see Section II). Bearing in mind the fact that the dip hitherto has been steadily to the north, through a vertical height of about 2,000 feet in the limestone series, it is evident that the thickness of this series must slightly exceed that amount at least. Furthermore, from evidence gleaned here and there on the hill-sides, it may be made out, as shewn in the section, that the northern limb of the synclinal is rapidly inverted, though we cannot trace this inversion everywhere on the steep ringal-covered slopes north of Ayarpata. The inversion is the precursor of the fold-fault which marks the boundary between the limestone and the slates, the latter appearing when the slope of the hill-side slackens in the neighbourhood of Aubrey Villa and Emily Cottage. These slates, although appearing to overlie the limestone, can be recognized as really the same as those we have already examined coming definitely beneath the limestone in the section between Kathgodam and Naini Tal. They agree with them in every respect petrologically, and their apparently abnormal position is really perfectly natural when we consider the manner in which the strata have been folded and faulted as exhibited in the section.

Synclinal with inverted northern limb.

We will call this fault the Ayarpata fold-fault for the sake of future reference. Calculating its "throw" from the relative thickness of the beds on each side of the synclinal we find that it averages at least 3,000 feet.

Ayarpata reversed fault.

So far in our ascents and descents; since leaving Giwalikhet we have been traversing over a block of strata possessing dips of various amounts but with a practically uniform strike. As may be seen on the map, the arrows indicating the dip are all turned towards or from one general direction and the amounts of dip are large, that is to say, from 40° to 60° with transitional dips near the Ayarpata fault of all angles between those amounts, and inverted dips of from 60° to 40°. On the bazar side of Giwalikhet, including the country about Sherwood, Rock-house, and the hill-sides south and west of Clarke's Bay, the strata on the contrary are practically horizontal, or with a rolling dip that does not accumulate much (see Section I). The line of division is necessarily a fault, and its direction is very well marked by a prominent line of gaps and hollows, extending from the hollow of Giwalikhet up the stream to the north-east between the Rock-house ridge and the eastern slopes of Ayar-

Country about Sherwood, Rock-house, and the hill-sides south and west of Clarke's Bay.

Giwalikhet cross-fault.

pata, thence to the gap near 6,969 bar., where there is a prominent change in the direction of the ridge lines, and thence across the lake to the Khairna road gorge. The effect of the fault is greatest to the south-west, and scarcely marked at all on the north-east side of the lake. For some distance the band of trap seen on the way up to Ayarpata follows the fault, then vanishes a little west of Rock-house, and does not again appear until a little west of St. Loo on the opposite side of the lake among slates. This fault we may call the Giwalikhet fault.

Ayarpata to Deopata and China.

Butcher's hill and Handi-Bandi hill.

Beginning our traverse where we left off in our last excursion, we descend by the landslip road, as it is called on the map, and notice the difference in soil and vegetation as we cross over the Ayarpata fold-fault, and enter on the slate series. On getting down to about the 7,000 feet level we turn through the gap in the ridge south of Butcher's hill, and find ourselves once more on the limestone formation. Moreover, we can see that from Butcher's hill along the north-west side of Sleepy Hollow, towards the quarries, there is a regular outcrop of limestone cutting by a cross-fault, over the strike of the slates to the east. Between Butcher's hill and Deopata comes Handi-Bandi hill, almost inaccessible on most of its sides, on account of the great masses of riven rock and tangled undergrowth which encumber the slopes. Nevertheless we can see that both Butcher's and Handi-Bandi hills are but miniature Deopatas, their general structure being almost exactly the same, especially on their southern slopes.

Deopata.

We proceed on towards Deopata, and find that the fold into which the rocks are thrown corresponds exactly to the similar fold remarked on the top of Ayarpata. The precipitous southern face is a dip slope of 55°, the dip steepening slightly towards the summit and then becoming vertical, and inverted at the great fold-fault which goes north of Ardwell and south of the Church. This great fold-fault is parallel to, and in its nature identical with, the Ayarpata fault, and both were doubtless produced together by one and the same earth movement. We will call this fault the Deopata fold-fault and the cross-fault the Sleepy Hollow cross-fault.

Oolitic limestone.

Some of the limestone forming the summit of Deopata is oolitic, the large grains at first suggesting fossils. The limestone is, however, perfectly unfossiliferous, so far as all investigations have gone. Looking down from the cairn along the line of fault we see, by reason of the vertical depth of the valley, how trenchant and important this fold-fault is, cutting as it does, clearly and sharply through hill and hollow alike.

China.

North of the Deopata fault, along the ridge towards China, we cross over very slightly inclined beds which express in their comparatively flat arrangement the great relief to the strata which accrued from the fault. There is a thin capping of massive limestone on the top of the ridge as far as the gap, where the road goes to Kilberry, and beneath it a regular and unbroken sequence of the slate series. Continuing straight up the ridge to China, there is much the same thing, slates beneath dipping 10° west-south-west or thereabouts, and a thin capping of massive limestone catching one point of the ridge only.

There is, however, another band of limestone of slightly different aspect coming among the slates, and some way beneath the main portion of the massive limestone. This thin band is exposed from the south China peak to the north China peak, in one line of outcrop. It is remarkable as at first appearing to be made up of very finely pulverised shells. Having subjected a portion of this to the microscope, I am able to state that this appearance is unfounded, there being not the slightest trace of any structure such as a shell in what is really a finely crystalline rock The same band of rock is also exposed at intervals along the south west side of China, and indicates that a complete layer of it truncates the topmost part of the mountain, though the precipitous nature of the south-east side prevents identification of it in that position.

Decaying scarp of China.

There are many points of analogy between China and the "landslips" inasmuch as each consists of a steep scarp of bedded rocks dipping at low angles and rapidly resolving into scree-material. The weather-worn face of China pared down and cut into by water-channels with only here and there a portion left sufficiently overgrown to give lodgment to a few cypresses, is throughout the rainy season in a constant state of disintegration. The outer crust of the precipice after becoming rotten by the soaking it has sustained crumbles away at irregular intervals, and becomes deposited as a talus at the bottom of the steeper part. Not seldom these small falls of rubbish from the high scarps may be heard many times repeated during the day. Last year (1889) a larger accumulation than usual took place along a line of cataclastic slate at the northern end of the lake fault, and in falling caused no small consternation to some of the residents in the vicinity. A scarp of this kind, however, can never become very dangerous. The constant shedding of small pieces of the outer crust affords the necessary relief which prevents the surface from working up for a great land-slip properly so called.

"Cirque" at the head of the Naini Tal valley.

The head of the Naini Tal valley from its amphitheatre-like aspect, doubtless merits the name of "cirque," since it is walled in on three sides by the Handi-Bandi hills, Deopata and China. From what I have described above with regard to the denudation here going on by streamlets it may be inferred that they have been sufficient to cause the cirque without calling in the aid of glaciers, or of underground springs.[1]

China to the Bleak House Spur.

Change of dip.

Leaving China behind us, and continuing down towards the ridge on which Government House stands, we find the slate series constantly with us. As we approach Fairlight Hall, there is to be noticed a gradual change in the direction and amount of the dip of the slates. Instead of being nearly west at low angles it becomes more south-west at 30° and 40°, reaching 60° locally. This change produces a necessary change in the sculpturing of the hill-sides. The scarps die out and dip-slopes begin to take their place (see Section II), some of which, south of Fairlight Hall, are very steep and with a convex outline.

[1] See Ball, Rec. G. S. of I., Vol. XI, p. 176.

Trap.

At Alma Lodge, in the gap south of Alma Hill, there appears a bed of trap of the same constitution as that found on Ayarpata. It is 20 yards thick, and dips with the slates 35° south-south-west. Near the junction with the slates it is somewhat slickensided. Most probably it is intruded along the bedding as in the case of the trap of Ayarpata. Since microscope sections reveal the identity of the two rocks, the fact of apparent bedding in the two distinct sets of strata is of itself sufficient to prove that the rock is not truly interbedded, but intrusive along the dip planes.

Extension of the trap.

As can be seen from the map, the trap dyke, as we may now call it, extends for a considerable distance in a north-westerly direction, keeping throughout its range in the map to a uniform aspect and thickness. A short distance south-east of Alma Lodge the Sleepy-Hollow cross-fault shifts the outcrop of the trap to the south-east face of the hill-side, where it may be traced only with difficulty for about $\frac{1}{2}$ mile on account of the soil and vegetation which clothe the slope to a large extent. It then either vanishes according to the nature of its intrusion, or it is cut off by the Deopata fold-fault. Whether there is a subterranean connection between this final appearance of it on this side of the lake and its appearance on the other side it is impossible to say.

Microscopical structure of the trap.

Microscopically the trap[1] is made up of plagioclase felspar, and augite, with alteration products hornblende and quartz, the latter filling the spaces between the other minerals. There are besides magnetite and a little apatite. The rock is holo-crystalline, and the felspars in regular crystalline forms, which are, however, changed into a grey, dusty-looking mineral, through which the twinning and polarisation colours can only be seen indistinctly. The augite is of very pale pellucid brownish-yellow colour, separated into irregular groups by the invading crystals of felspar. It therefore is without crystallographic outline. It is much cut up by widely open cleavage cracks parallel to the faces of the rhombic prism. Sometimes there are fairly distinct pinnacoidal cleavages visible. The augite is altered here and there into a bright green hornblendic or chloritic mineral faintly dichroic. The secondary quartz has been formed by alteration of the felspar, appearing sometimes interwoven with the felspar prisms at one side or end, though it also fills in spaces between the crystals. The rock very much resembles the Limeri rock[2] No. $\frac{7}{788}$, and also one from the Bhim Tal stream $\frac{3}{4}$ mile north of the Gola R.[3] No. $\frac{8}{337}$

If the latter resemblance indicates contemporaneity, then the intrusive position of the trap in the limestone of Naini Tal indicates that the basic traps so extensively developed in the neighbourhood of Bhuwali and Bhim Tal are also of later age than the Naini Tal limestone—a point that was left uncertain in my last paper.[4]

Dip slope in the slates.

The rest of the way along the hill-slope towards the Bleak House spur is over slates exposed with a slightly rolling dip averaging 30° down the hill-side. Thus the whole of this part of Naini Tal containing a great number of houses is built upon a dip slope which is so pecu-

[1] The rock sections here described were sliced by the Rev. T. D. Gray, M.A., Chaplain of Naini Tal, and kindly lent me for description.

[2] Records G. S. of I., Vol. XXI, p. 18.

[3] Ditto Vol. XXIII, p. 36.

[4] Ditto ditto p. 30.

liar in respect of the clean sweep that the hill-side makes down to the lake, as to have suggested to Mr. H. F. Blanford that it was due to the friction of a glacier. Later on, in this paper I shall shew reason for discarding the hypothesis that glaciers ever had anything to do with shaping the topography of this neighbourhood. A simpler explanation of this feature is to be found in the circumstance that isolated patches of the massive limestone are still left clinging to the surface of this dip slope, one at Sher-ka-danda, two more on the ridge between there and the Bleak House spur, and a great number of small ones (too numerous to be represented except diagramatically on the map) in the vicinity of the Bleak House spur. For a strong-bedded formation like that of the massive limestone which, judging from these isolated fragments, once extended probably in a rugged rocky mass over the surface of these slates, necessarily crumbled away under the action of alternate heat and cold and weathering, and eventually left an almost clean swept surface behind.

Convex slope of debris.

I have previously in this paper referred to the cleavage in these slates, and the smashed condition in which they are frequently found. On one part of the hill there is a great cake of superficial rubbish slightly cohering because of the calcareous tufa which is deposited among it, but which still, in the rains, sometimes partially breaks up and scatters fragments of limestone and slate down the hill slope. The surface of the slope here has become convex owing to this accumulation of debris, half arrested by the cementing influence of the carbonate of lime. It does not require the gift of prophecy to recognise this as the site of the next land-slip that Naini Tal will have to chronicle. For obvious reasons I do not mention the place more definitely.

Bleak House spur.

The Bleak House spur for many years has been the bug-bear of Naini Tal communications. It will be seen by the map to be in close proximity to the lake fault, and therefore within the sphere of the grinding and crushing which the softer rocks along the line of that fault have sustained. The rock, in fact, forming the Bleak House spur, has "gone into pi"; and partly owing to that circumstance, partly to the dip of the slate being down the slope, and partly to the slope being a junction slope for the massive limestone and the slate, it has been always in a state of collapse kept constant by the undermining action of the Balia stream carrying away the fallen talus. Hence the roadway round it can never be stable in the rainy months.

The outfall of the lake.

Many statements have been hazarded at different times regarding the material forming the dam at the outlet of the lake; and as a consequence a halo of mystery has unwarrantably gathered round the subject. Some authorities have stated that this dam consists of boulders and clay, the stranded moraine of a departed glacier; others, that it is the rubbish of an old landslip, which descended from the slopes to the east; whilst others have thrown out still wilder theories on the subject. But it is not of much moment to examine these different errors, the result chiefly of guess-work. The fact of the matter is, that beneath what is but a mere veneer of tumbled blocks in the bed of the stream, the material is what we should naturally expect, namely the rock *in situ*, normally continued from that which forms the foundations of the lower bazar. As coloured on the map, this rock is the hard massive limestone. It crosses the head of the Balia ravine, and is then separated by the lake fault from the slate series of Bleak House spur.

GENERAL REMARKS.

Faults and disturbance of the strata.

Let us now try to group together some of the scattered facts brought to light by our different excursions in and around Naini Tal. And first, as regards the faults, they may be divided up as follows:—

1. The Deopata and Ayarpata reversed fold-faults, with an east and west strike.
2. The Sleepy Hollow and Giwalikhet cross-faults, with a north-east or north-north-east strike.
3. The Lake fault.

Doubtless in and around the limestone hills there are a great many more minor faults that could never be properly recognised, but those enumerated above are the only ones which have had any structural part to play in the architecture of this part of the earth's crust. Secondly, as regards the contortion and folding of the strata (which are intimately connected with the faulting), we see that the whole of the area north of the Deopata fault, north-east of the lake fault, and south-east of the Giwalikhet fault is chiefly remarkable for the absence of any very striking folds. The lateral pressure exerted on the rocks here seems to have spent itself partly in the production of small irregular contortions in them and partly in cleaving them. In the vicinity of China, the general dip is very gentle indeed, seldom exceeding 10°; whilst all the part north-east of the lake and south-east of the Giwalikhet fault has also one gentle inclination not exceeding 30°; and usually in a south-west of west-south-west direction. A slight exception occurs near the south edge of the limestone crags at Manora and Hill View, where there is a dip to the north at low angles. This area of gentle inclination of the dip planes is very markedly in contrast to the two remaining areas of Ayarpata and Deopata, which have their strata dipping often at angles of as much as 60° with a steep and reversed synclinal near the Deopata and Ayarpata reversed faults respectively.

This seems to mean that instead of the whole of the Naini Tal area yielding alike to the influence of the lateral crushing to which the Himalaya have been subjected, and bending in regular folds of anticlinal and synclinal, there has been violent movement only in the Ayarpata and Deopata area, whilst the rest of Naini Tal has remained practically quiescent. It is plain that the great synclinal fold which must have been initiated somewhere about the centre of these two areas was, in the first place, prevented from carrying the strata on the east side of the Giwalikhet fault with it by reason of that fault. In other words the Giwalikhet fault represents the line of division between the violently moving strata to the west and the more quiescent strata to the east. In the second place it is equally evident that the synclinal fold was again broken along the Sleepy-hollow fault, one portion of the wave going further north and resting in the position of Deopata, and the other part remaining behind in the position of Ayarpata. The final condition then came about by the northern limb of the great synclinal (now divided into two by the Sleepy-hollow fault) becoming vertical, then inverted slightly, and then tearing a little north of the axis of the synclinal producing the Deopata reversed fault on one side and the Ayarpata fault on the other.

The connection of the lake fault with these movements is not however at all

manifest. It presents certain difficulties which cannot be entered into fully here, but I may mention that on the whole the balance of evidence seems to shew that it is the tail-end of a lateral displacement, due to a later earth-movement than any of the previous ones which we have considered. In my map of the Sub-Himalaya[1] it will be seen there is a great lateral fault running down the Balia ravine, and cutting the Gola River at Ranibagh. It is almost certain that the Lake fault and this lateral displacement are the effect of one movement, and most probably that movement was connected with the upheaval of the Nahan zone of rocks at a later epoch than that at which the other earth-movements which we have considered took place.

Viewing the folds and dislocations of the Naini Tal area in a still more general light, it is apparent that they represent an effort on the part of the strata to take up less horizontal room not only in a north and south direction, but also to a less degree in an east and west direction: that, in fact, there is a point situated about the position of the upper bazar towards which, as towards a centre, the waves of earth-movement have set in from north-east, south-east, and south directions. These efforts were not equal in all directions, the north and south effort was the most important as evidenced by the two east and west gigantic reversed faults. The south-west to north-east effort was less important, but is seen in the gentle dip south-west of the slate series on the north-east side of the lake, and on the two cross faults of Sleepy Hollow and Giwalikhet, whilst the south-east to north-west effort is seen in the general north-west dip at the edge of the limestone cliff south of Stone-Cross.

Origin of the lake.

Doubtless many a visitor to Naini Tal wonders how the lake itself came here, for lakes in the Himalaya are not numerous; the little cluster of the Kumaun Lakes, including, besides Naini Tal, Bhim Tal, Sath Tal, Naukuchia, and Malwa Tal, being a striking and peculiar feature of this part of the mountains. Ordinary ingenuity in such cases generally exhausts itself in an appeal either to fire or frost as a cause of the phenomenon. The deep little hollows in the hills are either attributed to the extinct craters of a volcano, or to the work of a glacier. The first of these however will most certainly not apply to Naini Tal, for none of the rocks in the vicinity are volcanic, nor are there any traces whatever that ashes, scoriæ, or lava were ever thrown up or exuded from its placid rim.

The glacier theory boasts more staunch adherents, and has been advocated by Mr. H. F. Blanford. It is a plausible enough theory on the face of it, but I have never been able to find a single fact to support it, neither moraines, nor *roches moutonnées*, and no trace of boulder clays or transported blocks.

Professor V. Ball in his paper "On the origin of the Kumaun lakes[2]" was similarly unable to find any proof of the glacier theory. It must be noticed, however, that his disbelief is largely centered on what he thought was a fact, namely, that the oultet of the lake was not solid, but made up of debris, such as a landslip might have heaped together. In other words, he thought there was no *rock-basin* such as could be attributed to a glacier. Mr. H. F. Blanford, on the contrary, saw the remnants of a moraine in the debris which he supposed filled up the outlet of the lake and held to the glacier explanation on that account.

I have shewn earlier on in this paper that there is undoubtedly solid limestone

[1] Memoirs, G. S. of I., Vol. XXIV, pt. 2.
[2] Rec. G. S. of I., Vol. XI, p. 174.

in situ at the outlet, that in fact there is a rock basin in a sense here, but still I am unable on that account alone to lend support to the glacier hypothesis.

I may perhaps mention here a few scratched stones set in a tough clay which I found at one point on the cart-road. At first sight they had a great resemblance to those in a true boulder-clay. Close examination shewed them to be mere imitations due to the movement of soil-cap over them; for the stones were only scratched on their upper surfaces, parallel to the exposed slope of clay, and the scratches and striæ were all directed down hill. On pointing them out to Mr. R. D. Oldham, he, though struck with the remarkable way they mimicked ice scratches, was perfectly convinced of their superficial origin due to the movement of soil-cap.

Fascinating, therefore, as are the volcanic and glacier hypotheses, I am afraid they must be relegated to that large limbo of plausible guesses which have not come true.

But now, having thrown aside fable, is there any more ordinary means by which the lake could have come into being.[1] And we must here realize that any gently-flowing stream in a valley would be converted into a lake by a raising of the lower, or a sinking of the more central, portion of a given area. Now the lower portion may be elevated in a variety of ways—by land-slips, by slow "creeping" of the soil-cap, or by earth-movements originating in a deeper cause. Also it must not be lost sight of that these three causes may merge into each other by gradations. A land-slip may be so slow as to become a "creep," and a "creep" so large and important as to merit the name of an earth-movement. The fault represented on the map east of the Balia ravine indicates a relative movement of the rocks, bringing about a broken up, cataclastic condition of them along the fault, although, so far as the limestone is concerned, the resulting slightly displaced masses of it are big enough and sufficiently held together in irregular stratified layers, as to still form a rock barrier that will stand long after the protective works constructed at that point have crumbled to dust.

Again, the more central portion of a flat valley may be deepened in a variety of ways—by eddies, by springs from beneath, by the breaking up of swallow-holes, or by earth-movements of an opposite tendency to those just referred to.

Let us now look at a few analogous lakes and tarns; there are Khurpa Tal and the two little lakes on the east side of the Balia ravine below the brewery, plainly stopped up by debris from above. They were once little valleys whose mouths have been stopped up by the great rush of fragments brought down to them by cross-drainage. It does not appear, however, that Naini Tal owed its formation to any such cause as that.

On the other hand, in and around Naini Tal, on the limestone, there are numerous little hollows which become lakes in wet weather. They are genuine basins in the solid rock, which have become lined with a nearly impervious clay. There can be little doubt, I think, that these at any rate, as I have before mentioned, owe their existence, first to swallow-holes, or subterranean cavities, which the rainfall of centuries has gradually made for itself by trickling down the joints or other fissures of the limestone. These might go on enlarging themselves perhaps for a considerable time, but sooner or later a smash would occur at the bottom of the hollow, and the passage would become partly choked up. Let us imagine it again and again being

[1] I pass over all details regarding the shape, depth, &c., of the lake as they have already been given by Prof. V. Ball in the paper alluded to.

enlarged, and again and again broken down, whilst all the time the drainage area was also gradually but surely enlarging itself, and we see that more and more clay would mingle with the limestone debris at the bottom of the hollow; until some day after a re-settlement there would be a complete stoppage of the water channel, or it would remain smaller than was able to carry off all the water entering it. We should then have a lake formed, which rising up to the lowest edge of the hollow would overflow, resulting in a condition similar to that of Naini Tal.

I see nothing preposterous in imagining some such origin as this for Naini Tal There is well-known to be a subterranean outlet above the Bull and Basin indicating that some water at least escapes from the lake at the present day by means of a fissure or swallow-hole. This escape may once have been the only outlet, which later had its channel broken in, or choked up, sufficient to allow the water to rise to its present level.

In the same way I might take the theory of differential earth-movements, and shew that they may not unreasonably have had a good deal to do with the formation of the lake. The lines of faults, which are numerous near the lake, are all lines of movement, on one side of which the strata have gone up and on the other side down A little more movement at one point either up or down would bring about the required effect; not to mention the probability that these lines of fracture, once started, would be made use of by water, and enlarged so as to become the starting points of swallow-holes.

Looking at the lines of faults more closely, we see that there is a point mid-way between Sukha Tal and the Upper Bazar, and another point a quarter of a mile north-west of Smuggler's Rock, from each of which three directions of fissuring cross one another at pretty nearly equal angles, making two stars of fracture. The centre of each star may well indicate a focus of movement, or point at which the main direction of tearing of the strata became altered and dispersed in this radiate manner. Such focuses would almost certainly be taken advantage of by subterranean waters, producing under-ground erosion and subsequent falling in, sufficient to account for the hollow now occupied by the lake.[1]

To pursue the matter further would be unwise. The origin of lake basins in nearly every part of the world in which they occur has long been recognised as a *crux*. To my mind the difficulty is not to account for the presence of lakes in among the hills, but to account for their absence over such large areas where some favourable opportunity one would think ought to have presented itself.

CONDITIONS GOVERNING MOUNTAIN SLOPES.

Difference between plateau country and true mountains.

In considering the natural dangers to which a hill-station may be subject in consequence of the action of geological agencies, we may dismiss everything applicable to plateau country, where the strata are generally inclined but a few degrees from the horizontal, and concern ourselves solely with such phenomena as may occur in an area of true mountains, where the inclination of the strata is generally severe, and where foldings, inversions, faulting, and crushing along

[1] In a foot-note (p. 181), Prof. V. Ball suggests that the basin of Naini Tal may possibly be connected with some local faulting, the existence of which is implied by the sulphur spring at the outfall.

lines of movement are common accompaniments. In such country there are no long stretches of level ground with intervening deep ravines and winding scarps; but there are a number of culminating points, from which main-ridges, side-ridges and side-spurs, with intervening streams, streamlets, and water-courses grow from one another like the branches of a tree.

A hill-station must largely occupy slopes.

It necessarily comes about that in a hill-station the great majority of the houses must be built on hill-slopes, whilst but a few can be accommodated on the ridges, and still fewer on the comparatively rare, flat "cirques" or bottoms at the valley heads. We have therefore to consider the safety or otherwise of *slopes* from a geological stand-point.

Slopes of 40° and over.

Every one who has had much practical experience of mountain climbing knows by an unerring instinct when the critical angle of about 40° has been reached in ascending a hill slope. It is that angle at which he must begin to climb cautiously and guard against a slip of the foot. It is also the angle at which large fragments of fallen rock lie in so unstable a position, that a touch will destroy their equilibrium and set them in rapid motion downwards. The terminal moraine of an actively shedding glacier is generally fixed at about this angle in its upper part, the huddled and jagged blocks being in a most precarious position. Scree material or talus, at the foot of a precipitous scarp that is in a state of rapid disintegration by frost, generally begins at this angle, and then lowers gradually. A slope, with an angle of 40 therefore, or anything above it, must be considered a dangerous one under any circumstances, and should never be built on unless it be but a few yards in height and forming part of a much gentler slope.

As a matter of fact few such slopes are ever built on, as, when not too steep, they are seldom clear of freshly-fallen blocks, uncovered by soil or vegetable growth; but for the sake of safety, the angle of 35° may very well be taken as the limiting angle subject to other conditions noted below.

Slopes of 25° and under.

In the other direction every slope below 25° may be considered safe, no matter what the structure or condition of the rocks, with perhaps a few rare exceptions.

Slopes at the debatable angles between 35° and 25°.

We have therefore by this simple elimination arrived at the debatable angles ranging between 35° and 25°. These are sometimes quite safe and sometimes dangerous: and they are those most frequently found in hill-stations in the Himalaya.[1]

Geological conditions of slopes.

The safety or not of these slopes depend on the following:—(1) *composition* of the rock; (2) its *condition* whether whole or shattered; (3) direction and inclination of the *divisional planes* which penetrate through the rock. Let us take these three in order.

Rock composition.

The composition of the rock is perhaps of least importance, and at all events can least be avoided, since the hill-station must make the best of the material on which it is built. By far the best and most lasting hill-sides in the Himalaya are those composed of the gneissose-granite and micaceous schists, so familiar at Ranikhet, Almora, and Kalandanda (Kalogarhi).

[1] Nothing is more deceptive to any one unaccustomed to deal with angles than the apparent inclination of slopes. Slopes of 60° are very often described as "quite vertical," and those of 70° or 80° as "overhanging". An instrument must always be used for determination.

From many points of view hill-stations on these rocks possess several advantages; for the rock, though stable and tough, is soft when first worked; roads and sites for houses can be cut quite readily in it; whilst the more fissile varieties afford abundance of excellent stone for such rough and ready buildings as are required. The soft sandstones of Nahan age, and all similar sandstones, such as the Murree sandstones, and the sandstones and shales of Kasauli and Dagshai come next in order of merit, but as they seldom rise about 5,coo feet they are not often likely to come within the sphere of a hill station.[1] Next in stability is the massive limestone formation, and all similar thick-bedded limestones and traps, which often afford very safe though rugged slopes. The rock as building material is, however, difficult to work, very absorbent of water, and sombre and unlovely to look upon. Last in order come all slates, shales and fissile varieties of quartzite and trap. These very seldom form good and trustworthy slopes, the material itself being very generally rotten, liable to rapid disintegration by the action of the atmosphere, and prone to become cut-back and to form those convex forms of slopes which are the most dangerous. In my wanderings in the Himalaya I have frequently seen old and new landslips of far greater size and destructiveness than that which occurred at Naini Tal in 1880, but I have always noticed that the slipped rock has been some form of slate or cleaved variety of trap.

Condition of the rock, its whole or shattered state.

In previous papers on the geology of the Himalaya, I have at several times drawn attention to the violent nature of those lateral thrusts and intense foldings of the strata, the concomitants of the upheaval of the mountain area. It is owing to these thrusts and foldings that lines of movement, or thrust-planes, have been started in rocks of all kinds, but more especially in slates and fissile rocks, along which a brecciating, shattering, or grinding up of the rock constituents has taken place. The rock in the vicinity of such lines is often reduced to a powder, or to an aggregation of fine fragments dispersed in a pasty matrix. When water gains access to these planes of weakness the rock returns to its original form of soft clay marl, sand, or gravel; it loses coherence with itself, and with the surrounding rock, and some form of slipping is inevitable. A very instructive set of local examples of this kind is to be seen in the neighbourhood of the Lake fault. Along this line intense grinding and crushing of the rock sides has taken place; as witness the condition of the rock at Bleak House spur, the subsidence of the cart-road below the Cemetery; the falls of limestone which have taken place near the Smuggler's Rock, in part also the slip near the Temples and that of China which took place in 1889.

All these points are points of weakness, more or less along the line of fracture of the lake fault, as can be seen by a glance at the map.

Crushing and shattering of a rock are however not always due to a fault. They frequently make their appearance in a thin-bedded or less rigid stratum in proximity to a very hard, thick-bedded stratum. The state at the position of the old Naini Tal landslip (1880) is of that character, partly due to the neighbourhood of the once superincumbent limestone, fragments of which may still be seen in one or two places on the hill-side not far away, and partly to the layer of hard trap beneath.

[1] As an exception to this, the associated purple shales or clays when obliquely exposed with a dip down hill are liable to cause some trouble from the soft miry condition into which they get after heavy rain.

The third is the most important of the three factors which go to make the slopes of between $25°$ and $35°$ safe or unsafe. The divisional planes cutting through a rock may be either directed down the slope, or in towards the hill, or in a direction between the two. As a general rule, however, on a slope of any importance, the dip is either down the slope or in towards the hill.

Direction and inclination of the divisional planes in the rock.

Figs. I, II, and III are examples of dip down the slope, and fig IV is an example of dip in towards the hill. The two first are those to be avoided, as likely to prove unstable and prone to slip. Of the two, the combination of dip and slope as seen in fig. I where the angle of dip is slightly lower than that of the slope is the more dangerous. This is easily seen to be due to the fact that in it the beds or layers of cleaved rock are cut away below, leaving a free edge which allows an upper bed to slide down over a lower; whereas in the case depicted in fig. II, a similar set of beds is shewn cut away above, leaving each bed with a firm basis of rock below it on which to rest. The third example (fig. III) shews a combination of a steep angle of dip coinciding in direction with the slope. Here the hill-side may be considered structurally much safer than that of fig. II. Finally, in fig. IV, the dip is shewn in the opposite direction or in towards the hill. This is the safest arrangement for all slopes fixed at the debatable angles of between $35°$ and $25°$.

In the diagram fig. V, *a b* represents the slope of the hill, and the radiating lines represent the different angles of dip. The thin lines shew the amounts of dip which in combination with the slope of the hill are dangerous, whilst the thick lines shew the safe amounts.

From this we see that dips between $15°$ and $45°$ in the direction of the slope constitute an unsafe hill-side. This may be expressed differently by saying that when the dip varies within $15°$ on one side or other of the angle of slope (taken at $30°$), it must be considered dangerous; and it is more dangerous when the angles of dip within the prescribed limits of $15°$ are less than those of the angle of slope, and less dangerous when they are greater.

When the inclination of a slope varies in amount, we have one or more convex or concave surfaces presented. The concave slopes, as a whole, are better than the convex ones. In the former the lower part of the slope and in the latter the upper part are relatively the safer.

Varying forms of slopes.

It is somewhat beside the scope of this paper to consider all the dynamical and physical conditions which are brought about in consequence of a given geological structure. Still it may be briefly pointed out that water plays a very active part in the actual starting of a landslip, and that the accumulation of surface debris, which often loads a hill-side with an unstable, heterogeneous mass of rubbish, is attended with much danger. Both these mediate causes are but the secondary results of an ultimate geological structure. For instance, a safe slope, as already defined, where the dip of the strata is in towards the hill, is obviously one on which water can have little to say, in consequence of the latter being drained away towards the centre of the base of the hill; whereas an unsafe slope, as already defined, in which the dip is down hill, is on the other hand one on which water will either emerge and form lines of springs, lubricating the under-surfaces of the strata (when the angle of dip is less

Mediate and proximate causes of slipping.

than that of the hill slope), or else will establish a hydrostatical pressure on the layers of rock and tend to wedge them off (when the angle of dip is slightly greater than that of the slope). In the same way, surface accumulation of debris, though taking place more or less on all slopes, seldom accumulates largely on a slope with the dip towards the hill, save when the angle of slope is very low, and therefore safe on that account. But it accumulates with dire effect on a dip slope, becoming a terrible menace to the safety of the hill-side, when eventually, through gradual "creeping" down the slope, or through cutting back of the hill-foot, it gives a bulged appearance to the slope such as Mr. R. D. Oldham[1] has described as the forerunner of the disaster of 1880.

Falling blocks.

It merely remains to mention cases in which falling blocks from a high precipice or scarp may become dangerous on account of the momentum they acquire on their downward journey. These are not generally of much account, and can easily be guarded against by flat terraces built above the houses, or trenches dug to receive them. Still a safe slope considered on the previous lines of argument may sometimes become dangerous on the above account, and it is well to keep in mind, therefore, that the distance to which falling blocks will travel is proportional (among other conditions) to the height from which they come and the angle of slope. Practically, it may be laid down that a block detached at a point on a precipice will be at rest before reaching a point on the slope below, such that a line joining the two makes no greater angle with the horizontal than 35°

Application of the above principles to Naini Tal

The following categorical summary has special reference to Naini Tal, and may be found of some practical use —

(1) The limestone formation, as a whole, (other things being equal) is safer than the slate formation

(2) The chief danger to apprehend on the limestone is the falling of loose blocks, or pinnacles of rock, during the rainy months. By blasting or knocking away any such loose blocks on slopes or precipices exceeding 40° they may always be rendered innocuous.

(3) Even when the hill-slope approximates to 35°, if the dip is in towards the hill, a limestone slope is less dangerous than one of 25°—30° in the slate formation when the dip is down hill

(4) On the north-east side of the lake where the dip and cleavage of the slates is often coincident with the slopes, both being at about 30°, more danger is to be apprehended from slipping than anywhere else in the station. Still, even on general slopes of this kind, there may be found plenty of local slopes of no greater angle than 25°, and these may generally be pronounced safe so long as the following warnings are attended to.—

(*a*) Never to build at the top of a concave, or bottom of a convex slope.

(*b*) To avoid lines of springs when the slope exceeds 25°.

(*c*) To avoid places where a brecciation, or great smashing of the strata has taken place along a fault or elsewhere.

(*d*) To avoid as a consequence of (*c*) places where accumulations of surface material are tending to give a bulge to the hill-side.

[1] See Rec G. S. of I., Vol. XIII, p. 277.

Note on some Fossil Indian Bird Bones, *by* R. LYDEKKER, B.A.

During a recent examination of the small series of Siwalik Bird bones preserved in the British Museum, I have been enabled to determine two specimens which have been hitherto unnamed. These are respectively the distal extremity of the right femur, and the proximal extremity of the corresponding bone of the opposite side, of a species of Pelican, which from their size I refer to *Pelecanus cautleyi*.[1] In woodcut 1 these two fragments are drawn alongside of the complete left femur of the existing *Pelecanus mitratus*, the proximal fossil fragment being reversed. It will

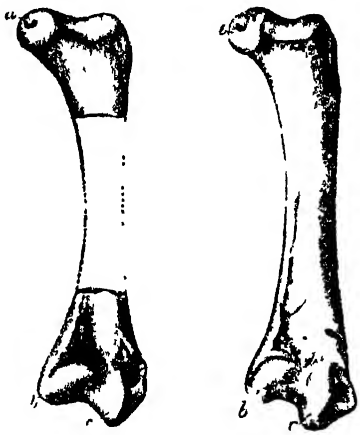

Fig. 1. Posterior aspect of the right femur of *Pelecanus mitratus*, and portions of the corresponding bone of *P. cautleyi*. ½ *a*, head, *b*, tibial condyle, *c*, fibular do.

be seen from the figures that the fossil fragments correspond so exactly with the recent bone, as to render it impossible to draw any good specific distinctions between the two. The distinctive characters of this species must, therefore continue to rest upon the well-marked features afforded by the type fragment of the ulna.

The specimen on which the smaller Siwalik Pelican described by Mr. Davies[2] as *P. sivalensis* was founded, having never been figured. I have remedied this omission by giving a full-sized figure in woodcut 2, in juxtaposition with the corresponding

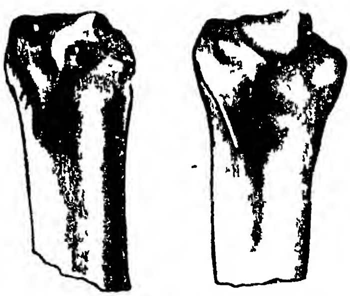

Fig. 2. Palmar aspect of the distal extremity of the right ulna of *Pelecanus sivalensis*, and corresponding portion of the homologous bone of *P. mitratus* ½. *a*, palmar trochlear depression.

[1] See Pal. Ind. Ser. 10, vol. iii, p. 137.
[2] See Pal. Ind. *loc. cit.*

portion of the ulna of the recent *P. mitratus*. As stated in the original description, this specimen differs from the distal extremity of the ulna of *P. cautleyi* by its inferior dimensions, the shallowness and shortness of the palmar trochlear depression (*a*), as well as in some minor points. The close general resemblance to the larger ulna of *P mitratus* is sufficiently apparent from the figures

Among the Bird bones obtained from the Karnul caves, I described and figured[1] some imperfect specimens of the tibio-tarsus and tarso-metatarsus under the name of *Ibis melanocephala* From a re-examination of some of these specimens presented to the British Museum, I find that this determination is incorrect, and that

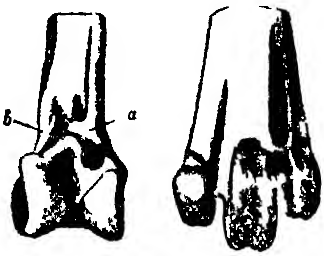

Fig 3 Anterior aspect of the distal extremities of the right tibio-tarsus and the left tarso-metatarsus of *Pseudotantalus leucocephalus* ½ *a*, bridge over groove for extensor tendons, *b* tubercle on same

they really belong to *Pseudotantalus leucocephalus*. In figure 3, the distal extremities of the tibio-tarsus and tarso-metatarsus of a recent skeleton of this species are given for comparison with the figure of the fossil bones The resemblance between the recent and fossil tarso-metatarsus is very close, but the latter being immature is rather smaller than the former. The figured tibio-tarsus indicates a considerably larger bird than the fossil tibio tarsus, the smaller fossil specimens of this bone described in the text agree, however, very closely with the figured recent bone, and the larger size of the figured fossil does not appear sufficient to indicate its specific distinctness.

[1] Pal. Ind. Ser 3, vol iv pp 53, 54

The Darjiling Coal *between the* Lisu *and the* Ramthi Rivers, *explored during season 1889-90, by* P. N. BOSE, B.SC., F.G.S., *Deputy Superintendent, Geological Survey of India.* (*With a map.*)

I.—PRELIMINARY.

In March, 1849, Dr. (now Sir Joseph) Hooker noticed near Pankabari some coal seams "six to twelve inches thick, very confused and distorted," and carbonaceous shales with plant fossils "characteristic of the Burdwan coal-fields." No notice was taken of these coal-bearing rocks until 1873, when the completion of the Northern Bengal State Railway gave to them a new importance. Mr. F. R. Mallet of the Geological Survey was in that year deputed to examine the coal and other mineral resources of the Darjiling Hill Territory. Mr. Mallet's survey brought to light a narrow band of coal-bearing rocks in the Sub-Himalayan range stretching from Pankabari to Dalingkot. In the "Memoirs of the Geological Survey," Volume XI, Part I, Mr. Mallet fully discusses the workability of the coal seams he came across. The decision arrived at by him, which is very forcibly expressed in a later paper in the "Records of the Geological Survey,"[1] is decidedly against the workability of the coal, so very decidedly, indeed, that, coming from one of the most careful observers the Survey has ever had, it was considered final.

Mr. Mallet rightly pointed out that owing to its flakiness the coal could not be utilised in its natural state,[2] and that this friable condition was due not to weathering, but to "crushing during the period of elevation of the Damuda rocks," so that no improvement can be expected at a distance from the surface. The Darjiling coal must, therefore, be artificially compacted before it can be used as fuel. This can be done in one of two ways, coking or conversion into *briquettes*.[3] Mr. Mallet's experiments with regard to the coking properties of the Darjiling coal were not at all hopeful. With regard to the conversion of the coal into patent fuel, his

[1] *Op. cit.* X, p. 143.

[2] Some of the Lisu valley coal was tried in its natural state by Mr. North of the Bagrakot Tea Estate, who says in a letter to me :—

" . . . . It burnt very well with wood, but alone it did not. This of course I put down to its being wet, and think better results would have been got if my furnace had not been so large; besides which the fire-bars were too far apart, and the coal went through."

With closely set fire-bars the coal may be used in its natural condition, but, I think, only to a limited extent, and at a short distance from the coal-field, where there will be little risk of repeated rough handling.

[3] The result of my experiments with regard to coke-making will appear in the sequel. With regard to *briquettes*, Messrs. Burn & Co. very generously lent me a small Boomer press originally intended for pressing tea-bricks. The coal-dust with which was mixed a little *bhutta* gruel (in the proportion of 1 maund to a ton of coal) was pressed into hard bricks. But they stuck firmly to the sides of the moulds; and as those were not hinged, the bricks could not be taken out without being broken. With proper moulds, the bricks, I have no doubt, could be got out undamaged.

experiments showed that it would probably be remunerative. They were, however, on a small scale, and "it yet remains to be proved," remarks Mr. Mallet, "whether this plan would answer on a commercial scale."

So the Darjiling coal was given up as hopeless. On the data before him, Mr. Mallet could have come to no other conclusion than what he arrived at. But Mr. Mallet's survey was very general. He had time only to go up some of the principal streams and notice the outcrops of coal that presented themselves as it were to him. It is possible that some important ones lay hidden in the intervening areas between the principal streams. Indeed, when it is remembered how thick the jungle is where they occur, and how obscure the sections are as a rule, such a thing appears highly probable. It was this probability, and the immense economic importance of the Darjiling coal, that led to my deputation to re-examine it last cold season. I made a general examination of the area between the Jít and the Tista, and a fairly detailed one of that between the Lisu and the Ramthi, where the coal seams gave the best promise of success.

I must say, when I started work, I had but little hope of finding workable coal The find, however, of thick seams of cakable coal in the Churanthi valley early in December appeared very promising, and it was considered desirable to ascertain their extent and thickness by excavations. The Government of Bengal was applied to for a grant of R2,000 for the purpose, which they sanctioned in March.

The coal-ground[1] being almost entirely in the Reserved Forest, is covered by very thick, nearly impenetrable, trackless jungle. The exuberant undergrowth of creepers, and the low, matted, dark scrub jungle, especially of cane, presented the most serious obstruction to vision and locomotion. The emanations from decomposed vegetation were at times almost intolerable. I had literally to cut down nearly every foot of my way; and clambering up the innumerable streamlets and watercourses was equally slow and tedious work. To add to these natural difficulties, the Revenue Survey Map of the area, though on a sufficiently large scale (2 inches to the mile), is neither accurate nor detailed enough for close work. Many streams are not marked; those that are, it is difficult to say if they are all correctly laid down; several do not certainly appear to be so. Scarcely any land-mark was available. One bridle-road passes through the explored area, along the watershed between the Lisu and the Churanthi. But it is not on the map; very likely it was not in existence when the survey was made. There are a few scattered hamlets north and west of the coal area; but they are not on the map, as they must have sprung up since its construction. So a new map had to be made, which is presented with this report. It is, I believe, fairly correct, and is on a sufficiently large scale to admit of details.,

The great difficulty experienced in the supply of labour, the almost absolute want of trained assistance, and the early setting in of the rains (about the middle of April), were amongst the other hindrances to the exploration. My progress would have been still slower, but for the cordial help which I received from Mr. A. W. Paul, Deputy Commissioner of Darjiling. My grateful acknowledgments are due to him and to the neighbouring planters, especially to Mr. J. L. Lister of the Nimbang Cinchona Plantation, for smoothing away many of my difficulties.

[1] I have made a number of bridle-paths which are practicable for ponies, though not without difficulty at places.

II.—PHYSICAL GEOGRAPHY.

Rivers and their tributaries.

The coal area explored in detail is two and three-quarters of a mile in length and about three-eighths of a mile in breadth. It is situated in the Sub-Himalayan range, about three to four miles from its foot. The Ramthi forms the eastern, and the Lisu the western boundary. The former joins the Jit, a short distance beyond its debouchure into the plains, together forming the Ghish river, a tributary of the Tístá. The Lisu, better known as the Lísh in the Duars, falls into the Tístá above Phulbári. Between the Lisu and the Ramthi, there is a third river called the Churanthi. It carries a good volume of water in the hills, but is barely traceable in the plains. All these rivers run in a general north-south direction across the strike of the rocks which usually varies between W.N.W.-E.S.E. and E.N E-W.S.W.

The rivers are parted from one another by narrow spurs running roughly parallel to them. Thus we have a spur, separating the Lisu from the Churanthi which may be called the Chankiang spur, after the nearest village, and the Nunmáti spur forms the watershed between the Churanthi and the Ramthi.

The streams tributary to the three rivers mentioned above run in a general east-west direction, being parallel to the strike, or cutting it obliquely. Of such streams, the most important is the Ramtek Jhora. It is also called Chunkhola,[1] as lime used to be made here some years ago. The other streams having mostly no local names have, for convenience of reference, been denominated A, B, C, &c.

Configuration of the ground.

The coal-bearing rocks (the Damudas), consisting mostly of rather soft fine-grained sandstones and slaty shales, form a sort of depression between high escarpments of hard quartzitic beds belonging to an older system (the Dalings) on the north side and those of massive conglomeratic, Tertiary strata on the south side. Indeed, the configuration of the Damudas may almost be followed with the eye. In the Damudas, again, spurs have been left where sandy beds prevail over the shaly, and as the coal is usually associated with the latter, one could tell by standing at a convenient position, not only how the Damudas run, but also where large seams of coal may be expected to occur, and where unproductive rocks preponderate most.

The depression between the Dalings and the Tertiaries in which the Damudas occur is roughly parallel to the strike of the rocks which, as has been mentioned before, usually varies between E.N.E.-W.S.W. and W.N.W.-E.S.E. The depression varies greatly in depth, the Chunkhola being the deepest in the explored area. The height of the Chunkhola near the ruined lime-kiln was found to be about 700 feet above the sea-level, and that of the spurs on either side of it about 2,500 feet. The coal outcrops occur at heights varying from about 700 to about 1,200 feet.

A consequence of the comparative softness of the Damudas is the widening of the rivers as they enter these rocks. The Romtal in the Ramthi is the best instance of such expansion. When Mr. Mallet saw the "lake" (16 years ago), it was very deep at its lower end. It has since entirely silted up; and a white mass of sand and shingle occupies the place of a once fine sheet of water.

[1] Strictly speaking, *khola* signifies valley, so that *chunkhola* would mean the entire valley of the Ramtek river.

As might be expected from the nature of the rocks, the rivers run through deep gorges in the massive Tertiary conglomeratic sandstones. Vertical precipices of these rocks, sometimes no less than 1,500 feet in height, tower majestically on either side of the rivers in awe-inspiring silence.

Fall of the rivers, &c.

The Damudas, as a consequence of their comparative softness, are cut through by anastomosing streams, streamlets, and watercourses, which is a distinct advantage in the tracing of the coal outcrops. This advantage is, however, to a very great extent neutralised by the covering up of the Damudas by detritus from the Dalings and the Tertiaries. The fall of the rivers, streams, and streamlets increases in the order they are named, that of the minor streams being the greatest. The streamlet C, for instance, a tributary of the Ramtek Jhora or Chunkhola, which has its source just below my head-quarters camp, measures about half a mile in length. Within this length the fall is from about 2,500 feet to about 750 feet, that is to say, about 1 foot in 1½ feet.

As a consequence of this immense fall, huge slips take place during the rains; to such an extent, indeed, that it is often difficult to say where the rock is *in situ*, and where not. Consequently, the exact demarcation of the different systems of rocks is a matter of the greatest difficulty. The sections in the streams are seldom continuous for any considerable distance being hidden by talus; good outcrops of coal are never exposed in them. The rivers bring down huge masses of rock, some measuring 20 feet or more across, from long distances. Thus we have big "boulders" of gneiss in the Lisu and the Jít (a river a mile east of the Ramthi) very nearly down to their debouchure into the plains, at a distance of some eight miles from the parent rock. Immense "boulders" carried from longer distances are met with in the larger Himalayan rivers, such as the Tístá and the Rangit. The "boulders" are transported not so much, I believe, by the force of the current, as by the cutting away of the ground under them, so that they topple over and are rolled down.

Climate.

With regard to climate, the rainfall of the area is very heavy. The average of seven years from 1883 to 1889 at Nimbang just north of the coal-area is 194·87 inches, which is considerably greater than that of Darjiling. Last year the rainfall at Nimbang was 245·83 inches. The following details have been kindly supplied by Mr. J. L. Lister of the Nimbang Cinchona Plantation:—

Rainfall in inches.

	Jan.	Feb.	Mar.	April.	May.	June.	July.	Aug.	Sep.	Oct.	Nov.	Dec.	TOTAL.
1885 .	0·43	0·13	2·66	2·92	10·71	30·92	70·64	43·04	35·19	5·68	0	1·15	203·47
1886 .	0	0·11	4·02	0·91	11·88	38·13	47·12	60·71	24·58	5·78	0·44	0·64	194·32
1887 .	5·04	0	1·60	5·12	21·02	44·13	34·26	47·48	29·43	7·87	0·15	0	196·10
1888 .	0·88	0·50	2·82	4·69	7·35	35·56	51·05	30·78	25·51	2·36	0·48	0	161·98
1889 .	2·85	3·82	0·05	4·43	11·93	60·82	80·66	45·99	23·95	9·33	2	0	245·83
1890 .	2·02	0	0·30	5·58	6·21 (up to the 28th).								

The temperature decreases, and the salubrity of the climate increases with altitude. From the middle of April to about the end of May, I had my head-quarters camp on the highest peak of the Chankiang spur north of the Chunkhola, at an elevation of about 2,600 feet. Within that period, the temperature seldom rose above 80°. But, the place being exposed on all sides, and the weather rather showery, the changes of temperature were sudden and great. For permanent quarters, more sheltered sites will be found on either side of the spur.

III.—GEOLOGY.

For detailed information on the geology of the district, the reader is referred to Mr. Mallet's comprehensive memoir. I shall here chiefly refer to such facts as have been brought to light by the excavations.

The Damudas: sandstones and shales.

The coal-bearing rocks (the Damudus) consist essentially of sandstones and shales, the former predominating. The sandstones are greyish, rather soft, massive-bedded, medium-grained, felspathic, and occasionally calcareous They are never pebbly; and this constitutes the most important point of difference between them and the adjacent Tertiary sandstones. False-bedding is common. Along bedding and joint planes, they are not unoften seen to be thinly crusted over with carbonaceous matter; but the vegetable impressions are never very distinct. The shales, as has been already mentioned, are subordinate to the sandstones. They are sometimes coarse, being sandy and micaceous, when reddish tints prevail; sometimes very fine and black, breaking with conchoidal fracture. They are, as a rule, more or less carbonaceous, the black shales being most so; and it is in association with these that coal seams occur.

Mica Trap.

Igneous rocks occur; indeed, would appear to be rather common. Like those which I have described from Barakar and Raniganj,[1] they abound in mica (biotite), and are "mica traps."[2] That they are intrusive is shewn by the hardening of the sandstones, shales, or coal in contact. The contact coal, as at Barakar, usually occurs in columns, which are dull in colour, and rudely hexagonal; sometimes it is found to be hard and peculiarly lustrous. A good intrusive sheet of "mica trap" is seen in the stream D, 7 feet in thickness, just below pit No. 9. It is traceable for a short distance dipping with the associated coal and following the change of strike. Other thick outcrops of "mica trap" were observed near pit No. 11, west of the Nimbang-Bagrakot road, in the Churanthi, and in the Nunmati stream between the Churanthi and the Ramthi. From the nature of the associated strata and their lie, all these outcrops appear to belong to the same sheet as that in the stream D, near pit No. 9. If so, they mark a good horizon. The coal beds in contact with the "mica trap" are pervaded by anastomosing veins of a reddish or brownish rock. It has a "felsitic" look, but the specimens obtained being all much decomposed, its petrography is at present unascertainable; and owing to the extreme obscurity of sections, I am doubtful about its relation to the thick sheets of "mica trap." I may note that I nowhere saw the "mica trap" cut distinctly through the sedimentary strata. But,

[1] Rec., Vol. XXI, pt. 4, p. 163.

[2] The felspar being much decomposed, it is difficult to say whether the mica trap is Minette or Kersanton.

owing to the smallness of the explored area, and the wretchedness of the exposures, not much reliance can be placed on this negative fact.

Age of the Mica Trap

With regard to the age of the "mica trap," it must have been posterior to the deposition of the coal-bearing rocks, at least the greater portion of them, and anterior to the disturbances they underwent, as well as to the deposition of the adjacent tertiary rocks. For the mica trap, or, indeed, any other igneous rock, was nowhere found among the last-named rocks; and, as has been observed before, the intrusive sheets dip with the associated coal and sedimentary strata, and follow their strike.

Dip, strike, &c.

All the rocks have been greatly disturbed. The dip is usually very high, from 45° to near verticality; it is seldom lower than 30°. The strike is very inconstant. In the explored area, the usual strike ranges between E.N E.-W.S W. and W.N W.-E S.E., the dips pointing from N.N.W. to N.N E. But, sometimes, as in the Chunkhola, near the junction of the stream F, and in the Lisu valley at pit 1, the strike is nearly N.—S. Sharp twists in the strike were observed at diverse places. There is also faulting to a great extent; but owing to the ground being much covered up, the faults were nowhere well seen, except in the case of some small ones exposed by excavations; and the course of the faults as given on the map must be taken as more or less conjectural.

As a consequence of the disturbance which the beds have undergone, the rocks have been greatly crushed, the crushing effect being specially noticeable in the shales and the coal. The former have been converted into extremely fragile, splintery slates, which break in all conceivable directions, and a flakiness has been induced in the coal, so that with the least violence it is as a rule reduced to small bits, if not to absolute dust.

Age of the coal-bearing rocks.

Mr. Mallet is inclined to correlate the Sub-Himalayan coal-bearing rocks with the Raniganj stage of the Damuda series I have nothing to add to his discussion on this point.[1] On account of the great crushing which the beds have undergone, the plant-fossils have been very badly preserved. I could collect anything like a respectable number of them from only one place, pit No. 2 in the Lisu valley. They appear, however, to belong mostly to one genus—*Vertebraria.*

Tertiary rocks

On the south side, the Damudas are in contact with the Tertiary rocks. These consist chiefly of micaceous, felspathic sandstones and conglomerates. The conglomerates are coarse, sometimes very much so. They are best developed near the junction of the Tertiary and Damuda beds. The sandstones have usually a brownish hue: they are, sometimes, though rarely, highly ferruginous. The sandstones and conglomerates are as a rule very thick-bedded. Clay beds, sometimes highly ferruginous, occur, but are quite subordinate. These and the sandstones are met with below the conglomerates, that is to say, at the base of the Tertiary system. Small pockets of coal[2] and

[1] *Op cit.* p. 29, *et seq.*

[2] A specimen of this coal was analysed and found to contain moisture 17·52, volatile matter exclusive of moisture 31·88, fixed carbon 49·28, and ash 1·32. It is noteworthy that the analysis of this coal agrees very closely with that of fragments found in 1837, during some boring operations, in Fort William, at a depth of 392 feet (see Man. Geol. of India, Vol. III, p. 77). There can be scarcely any doubt that these fragments were derived from the Tertiary coal of the Sub-Himalayan range.

lignite are found in the sandstones, as in the Ramthi and the Jit. But no workable seam of either has been found anywhere; nor is any such seam ever likely to be found.[1] No fossils beyond unrecognisable vegetable remains have been found in these rocks. But from their lithological characters, and from the presence amongst them of lignite sandstones, Messrs. Medlicott and Mallet concluded that they represent the Nahan stage of the Siwalik series.[2]

The Tertiary strata have a general north-western dip. Their strike is more constant than that of the Damudas, and the dip also (except sometimes at their junction with the latter rocks) lower and more uniform, seldom exceeding 30°, and seldom deviating much from N.N.W. The sál-clad massive sandstones and conglomerates forming craggy ridges are beautifully seen to slope with the dip, and can be followed with the eye to long distances.

The Damuda—Tertiary boundary.

The Tertiary and Damuda strata both having as a rule northerly dips, the former, though more recent, appear to underlie the latter. Good contact sections are rare. As the relation of the two sets of rocks is of immense practical as well as theoretical importance, I shall here give in detail some facts bearing upon it.

Commencing with the westernmost part of the explored area, near streamlet L, a tributary of the Ramtek Jhora, a wall-like bed of massive tertiary conglomerate, is in contact with Damuda shales[3] and coal. The dip of both is high, about 70°, and points north-westward; so that the tertiary conglomerate appears to underlie the Damuda shales. I had a pit dug at the junction, pit No. 20. It went down to some 20 feet, the conglomerate and the coal-bearing rocks being found all the way in contact as at the surface. Here we have very likely a reversed fault.

There is nothing particularly noteworthy about the boundary between the streams L and F. Near the junction of the latter stream with the Ramtek Jhora, the boundary line becomes tortuous; and there is also discrepancy in strike, the coal-bearing rocks at and south of pit No. 65 striking very nearly N.-S., whereas .. such change of strike was observable in the abutting Tertiary strata to the south. E. of pit No. 65, the boundary line runs fairly straight nearly as far as the Bagrakot-Nimbang road. The junction along a portion of it, south and south-west of pit No. 11, is well exposed. Here the Tertiary strata have been much crushed; and they abut against the coal-bearing rocks in a manner which, coupled with the straightness of boundary, gives rise to a strong suspicion of faulting. I am inclined to think that we have a reversed fault here.

Between the Bagrakot-Nimbang road and the Churanthi river, the boundary line is far from straight, and the facts as revealed by excavations do not favour the idea of faulting. Just east of the road the Damudas bay into the Tertiaries. Further east, the coal of pit No. 7, at the junction of streams D and D[1], distinctly passes under Tertiary conglomerates and sandstones. The pit between Nos. 7 and 39 went through some 30 feet of the latter rocks; below these coal was struck, which, I have hardly any doubt, belongs to the same seam as that exposed in pit No. 7. The seam,

[1] It is necessary to emphasize this. Owing probably to the proximity of the Tertiaries to the Duars and the Terai, more notice has I find been taken by the planters of these pockets of Tertiary lignite than of the seams of Damuda coal.

[2] "Mem.," Vol. XI, pt. 1, p. 50

[3] I must say, no fossils were found here. But the shales and the associated coal have an unmistakably Damuda facies.

which is exposed by a number of pits between 75 and 41, passes, when traced southward, at 39, under Tertiary conglomerates. There is just a skin of these about 39; but they increase rapidly in thickness southward. From the sections in the pit 39 and that between it and 7, the Tertiaries are seen to rest upon a very uneven surface of the coal-beds; the latter had been denuded out into hollows before the former were deposited. There would also appear to be diversity of strike. The sections here suggest simple unconformable superposition. East of 39, the boundary line runs fairly straight as far as the Churanthi river. Here the Damudas bay into the Tertiary beds in such a manner as to leave little doubt concerning the unconformable superposition of the latter. Some coal of rather good quality was obtained by digging through the Tertiary sandstones by the side of the stream M (a feeder of the Churanthi), which I am inclined to think belongs to the seam exposed in pit No. 7, or to that just north-east of it. The Tertiary conglomerates and conglomeratic sandstones in the intervening area were found too thick and too hard to settle this important point by diggings. Two or three borings here will be of great practical and theoretical interest. The ground east of the Churanthi was not explored in such detail as that to the west of it; and the boundary line being more or less conjectural is drawn fairly straight as far as the Ramthi. I have no doubt that, with more detailed exploration, the Damudas will be found to bay into the Tertiaries at places.

It will be seen, from what has been said above, that the boundary line between the Tertiaries and the Damudas, though it appears fairly straight on a small scale map, is sometimes very crooked. There is faulting at places; but the facts noted above do not favour the idea of the entire boundary being a fault. This conclusion appears to be in accordance with that arrived at by Mr. Medlicott in the North-Western Himalayas, who believes the junction between the Tertiaries and the older rocks there to be "primarily a line of original contact."

The Dalings.

On the north side the Damudas are in contact with the Dalings. The junction is much covered up, more so than that with the Tertiaries just treated of; and the boundary line being for the greater part more or less conjectural may not be quite so straight as shewn on the map. In the Chunkhola the junction is fairly well seen in the streams B, C, D. Close to it the Dalings consist of impure limestones and of slates which are partly ferruginous and partly carbonaceous. The latter have a small percentage of carbon, one of the samples analysed shewing only 5·2 per cent. of fixed carbon. The carbonaceous slates occur in association with thin foliæ of white quartz; and the rock may be called carbonaceous quartz schist. This schist is usually well developed near the junction. Further north, silvery slates, quartzites, &c., occur. The limestone mentioned above occurs just at the junction. It is poor in lime, as the following analysis by Mr. P. Lake will shew:—

SiO_2 and insolubles	53·10
Fe_2O_3 and Al_2O_3	2·45
CaO	23·77
MO	·70
CO_2	18·65
H_2O	·58
	99·2

The Damuda-Daling boundary.

The Damudas and the Dalings both dipping northward, the former, though more recent, have the appearance of underlying the latter. This appearance is rendered the more deceptive owing to the uniformity of dip (both in amount and direction) presented by both of these series, and owing to the occasional lithological similarity of some of their constituents. As a rule, however, and especially away from the junction, the petrological contrast between the two series is marked, and when the boundary is not covered by talus, it is not difficult to demarcate it. The Dalings are, as a rule, far more advanced in metamorphism than the Damudas.

With regard to the boundary between the Damudas and the Dalings, it may be partly, like the Damuda-Tertiary boundary, a reversed fault. As, however, but few excavations were made along the former, the observations regarding it are not of such a satisfactory character as those relating to the latter.

Conditions of deposition.

The presence of carbonaceous beds in the Dalings probably indicates that estuarine and terrestrial conditions had already set in during the Daling epoch. These conditions certainly prevailed during the Damuda epoch and the Tertiary period, when there were laid down carbonaceous shales, coal, and false-bedded sandstones in the former, and coarse conglomerates, lignitiferous sandstones, &c., in the latter. Indeed, the same conditions appear to have lasted up to the present day.

IV.—ECONOMIC GEOLOGY.

§1. *Principal Coal Seams.*

The ground immediately to the east of the Kalimpong-Bagrakot road was explored in greater detail than any other portion of the Damuda area. I shall, therefore, start with a description of it.

The Churanthi Valley.

At pit No. 7, there is exposed a good seam of coal 16 feet in thickness. It has a high north-eastern dip amounting to 70°. It rests upon fine micaceous, more or less carbonaceous, arenaceous shales about 8 feet in thickness. Below these shales, a thick outcrop of coal is exposed in the streamlet D[1]. I at first took it to belong to a distinct seam; but by diggings it was found to be only the 16 feet seam sharply twisted back. On the north side, this seam is faulted against another, about 6 feet in thickness, resting upon shales about 4 feet thick, and dipping nearly vertical in a south-western direction. Eastward, a pit along the strike (between Nos. 7 and 39) disclosed what I believe to be the 16 feet seam coal under some 30 feet of conglomeratic Tertiary sandstones. Further east, these sandstones were found too thick to attempt diggings. The 6 feet seam which is faulted against the 16 feet seam in pit 7 was traced by diggings for a short distance westward, after which its course in that direction was found to be cut off by a fault.

Sixty-two feet north of the seam last mentioned there is a thick seam resting upon sandstones. It was traced through pits 75, 60, 43, 42, 41, and 39, almost continuously for about 340 feet. From the sections in pits 41, 42, and 43, it is found to be about 24 feet in thickness. The dip is north-eastern and varies from 40° to 45°. Near 75, the strike takes a twist and changes from nearly N.W.-S.E.

to N.E.-S.W. The seam is traced down to the stream D, near which there is in all likelihood a minor fault. South of the stream D, we have a good seam exposed by pits 22 and 6. In pit 6, it is about 17 feet in thickness and rests upon shales with inter-bedded thin coal. The dip varies from 40° to 55° in amount, and from N.N.W. to N.W. in direction. I believe the seam is identical with the 75-39 seam.[1] The former was traced to pit No. 87. Proceeding south-west along the strike, we have a good seam exposed by pits 38 and 51. The trench at 38 cutting the strike very obliquely, the thickness of the seam is doubtful. It cannot, however, be much less than 25 feet; and, like the seam 6-87, I believe it is identical with 75-39, in which case, we have got this seam traced for a distance of some 800 feet, without any diminution of its thickness.

The last-mentioned seam is superposed by sandstones which are fairly well seen in the stream D. Several minor coal seams and sheets of "mica trap" are found in these. Just below pit 9, a thick sheet of the mica trap is met with. It is overlaid by coal which extends with but little interruption to pit No. 8 for a distance of about 80 feet. Of this coal, that in immediate contact with the mica trap is worthless as fuel being very hard and columnar; further beyond, in pits 9, 21, and 8 a seam of coal of inferior quality is exposed, averaging about 18 feet in thickness. Similar coal is exposed in pits 10, 45, and 27 by the stream DD[1]; it is very likely the continuation of the 8-9 seam. In fact, I believe, it is continued to the Churanthi as shewn on the map.

The coal of No. 9 is parted from a seam of good coal (pit 104) by a few feet of shales. This coal is about 5 feet in thickness, dips N.W. 45°, and is overlaid by sandstones. There can be scarcely any doubt that it is this coal which is caught in pit No. 46, where the thickness is about 7 feet. It is probably continued through pit 28 to the Churanthi (pit 105). In the last-named pit, however, the coal is of inconsiderable thickness.

A seam of good coal is exposed in pits 47, 48, and 49, of which the thickness in pit 48 is 8 feet, and in pit 49 is 9 feet. It would probably be found to run parallel with the last-mentioned seam at least to some distance westward.

The coal of pit No. 7 as well as of the seam 75—39, traced along the strike eastward, passes under thick Tertiary rocks. By the stream M, close to its junction with the Churanthi, there was disclosed some good coal in pit 95, which, I am inclined to think, is identical either with the coal of pit No. 7, or with that of the seam 75—39. The Tertiary rocks in the intervening ground were found too thick to attempt any excavations: two or three borings would settle the question of the identity satisfactorily. In the meantime I may give the reasons which led me to believe in it.

First.—There is a thick outcrop of mica trap, 300 feet north of pit No. 95, which seems to be the same as that found in the stream D below pit 9; for it is overlaid by altered coal and other rocks similar to those superposed on it in the stream just named. The relative position of the coal of No. 7 or of No. 75 with regard to the mica trap is the same as that of No. 95.

Secondly.—The strike which all these rocks have when last seen near pit No. 39 would bring them to the position occupied by them between the stream M and the Churanthi.

[1] That is to say, the seam lying between pits 75 and 39. For the sake of brevity, I shall refer to seams in this way.

The Ramthi Valley.

Between the Churanthi and the Nunmati stream, the ground is much covered up and was not explored in detail. Some diggings were made by the last-mentioned stream. A trench at 93 exposed the following section in descending order :—

8′ anthricitised hard *coal*—Dip N. 50°.
4′ intrusive sheet of mica trap (?)
6′ altered hard *coal*.
12′ good *coal*.
11′ *coal*, partly altered, partly shaly.
Shales more or less carbonaceous.

As the strike between the Churanthi and the Nunmati stream (a feeder of the Ramthi river) is very steady, being E.—W., I am inclined to believe that the coal of No. 93 is the same as that of 95 by the stream M.

Further up the Nunmati stream, several seams of coal, more or less worthless as fuel, and intrusive sheets of mica trap (?) are met with, until near pit 91, where thick sandstones are met with. At pit 91, there is a seam of good coal about 6 feet in thickness, dipping N.—10—E. ·45°.

East of the Nunmati stream the trend of the strike changes from nearly E.—W. to E. N. E.—W. S. W. by the stream E, and to nearly N.—S. by the stream P, where the dip at pit 33 is westerly. This pit exposes a seam of rather good coal 10 feet thick dipping 70° W. Below it there is another seam of indifferent coal (pit 32) about 7 feet in thickness. In pit 30. by the Ramthi, there are two seams, of which the upper is 10 feet in thickness, and the lower varies from 2 to 5 feet. The dip is western.

The Chunkhola.

Going back to the Bagrakot-Kalimpong road, we find about 160 feet west of it, near pit 11, a thick sheet of mica trap overlaid by columnar and otherwise altered coal. I am strongly inclined to think that it is identical with the thick sheet mentioned above as occurring in the stream D below pit 9. There are indications here of the mica trap being [illegible]lted against the Tertiary conglomerates.

Proceeding along the strike westward, the mica trap is traceable for a short distance south-west of pit 62. Further beyond, the ground near the junction is much covered up, and there is nothing specially noteworthy south of the Ramtek stream until we come to pit 65. The section here in descending order is as follows :—

Micaceous sandy shales.

27′ good *coal*. } Dip E.N E. 30°
25′ sandy shales. }
30′ good *coal*.
Sandstones. Dip E N.E. 85°.

Taking the average dip of the lower seam, which is higher than that of the upper, at 50°, we get its thickness to be 22·8 feet. The thickness of the upper seam, if the dip (30°) of the underlying shales be taken, is 13½ feet. Both of these seams were traced northward to the Ramtek river where they are lost, probably cut off by a fault. Southward they were traced to the stream F, where they either pass under, or are faulted against, the Tertiary rocks, the question being left unsettled owing to the difficulty of sinking pits in these. The actual length over which the seams are traced is 340 feet.

The sandstones underlying the lower of the two seams just mentioned have a very high eastern dip bordering upon verticality. They are seen for a short distance west of the coke-kiln where they are faulted against coal-seams, carbonaceous shales, &c., running with a very different strike (nearly E.-W.). The ground is much covered up by debris of Tertiary conglomerates, and is, besides, confused by faulting and contortion. By ripping it open several thick seams of excellent coal were exposed. Just by the stream F, at pit 25, a very thick seam is exposed. In a trench dug nearly across the strike its outcrop measured no less than 40 feet. Taking the average dip at 50°, its thickness would be 30 feet. Westward, the ground was not sufficiently well opened up to enable me to say with certainty how it ran in that direction; and its relation to the seam just north-west of it is very doubtful. Possibly the two seams are identical, one being slightly shifted from the other by faulting. Eastward, the seam of pit 25 is faulted against the sandstones underlying the bottom coal of pit 65.

A trench across strike at pit 36 exposed the following section in descending order:—

22' good *coal* (lower part somewhat stony). Dip N.-10-E. to N.-10-W., 40°.
16' shales.
29' good *coal*. Dip N. 45°.
Shales.

The thickness of the upper of these two seams is about 15 feet, and that of the lower seam about 20 feet.

Both of these seams agree very closely with those exposed east of the coke-kiln in thickness and quality as well as in the fact of their being parted by shales. I think it highly probable that the seams of pit 65 have been brought to the position they occupy in section 36, first by a twist in the strike south of the stream F, and then by faulting.

The upper seam of pit 36 is much covered up by debris of Tertiary rocks. Digging through these to a depth of some 20 feet, it was seen to be apparently faulted against another seam of excellent coal, which at pit 56 dips E.S.E. 50°. The thickness of the latter seam is about 17 feet. It is continued westward to pit 35, where a twist in the strike takes place, the dip changing to E.N.E. 55°. The thickness as measured here is slightly greater amounting to about 20 feet. It is apparently faulted against another seam of hard, altered coal, below which we have some excellent coal, about 13 feet thick, resting upon sandstones and dipping E.S.E. This coal is, I believe, continued to pit 13 at the junction of the stream F and the Chunkhola.

The ground just described (containing pits 65, 25, 36, 56, 35, and 13) is very rich in excellent coal-seams. On the data available, any attempt to identify them with the seams exposed between the Kalimpong-Bagrakot road and the Churanthi would lead to too much speculation, which I have tried to avoid. I may, however, just observe that a thick outcrop of mica trap occurs between pit 54 and the junction of the stream K with the Ramtek river. If it be permissible to identify it with the mica trap near pit 11 by the Bagrakot-Kalimpong road, then the seams exposed tin pit 65 may be identical with the coal-seam in pit 38.

South-west of the stream F, there is notning specially noteworthy until we get to the stream L. Between its junction with the Ramtek river and pit 20, there were

found indications of good coal-seams. This ground, however, was not explored in sufficient detail.

Going back to the Bagrakot-Kalimpong road, we find some 400 feet west of the Kuli huts a rather promising seam exposed by pit 5. It is about 14 feet in thickness, and dips E.—10—N. Southward, the ground being much covered up, it could be traced but for a short distance. There are indications of coal near pit 61, but none of respectable thickness was encountered. The dip here is also eastern. But at pits 62 and 11 the beds of altered coal (mostly columnar) are inclined N.N.W. I am inclined to think that a line of fault runs between pits 61 and 62, and extends to some distance westward, probably as far as the junction of the stream II with the Chunkhola. There is very likely another line of fault running along the spur, dividing Chunkhola from the Churanthi valley; for the rocks on either side of it present great discordance both as regards strike and lithology. On the Bagrakot-Kalimpong road and east of it the dip is north-western; whereas west of the road it varies from E—18—N to N.E.: and the seams occurring west of the road—that of pit 5, for instance—are not to be found east of it.

Proceeding westward from pits 5 and 61 we have in pits 68 and 34 indications of good coal. Further west there occurs in pit 29 an excellent seam. The section here is as follows (in descending order):—

Shales.
2' good *coal*.
9" shales.
14' 3" good *coal*.
Blackish carbonaceous shales.

The dip is E.N.E. 45°. Taking this dip, the thickness of the lower seam comes to about 10½ feet. Lower down the streamlet in which pit 29 lies, another seam of good coal was exposed by diggings (pit No. 53). It has a thickness of about 6 feet, and strikes nearly E.—W.

Proceeding westward, some very good coal was exposed by diggings by the stream G (pits 69 and 59). A cross cut at 69 exposed the following section (in descending order):—

1' *coal*.
1' 3" shales.
38' 9" *coal*, dip N. to N.—10—W. 65°.
4' carbonaceous black shales.
3' grey sandy shales.
3' carbonaceous, oily, black shales, Dip N 80°.
Sandstones.

If the amount of the dip be reliable, the thickness of the main seam comes to no less than 35 feet. As regards the quality of the coal, it has a very strong resemblance to that of pit 29; and the strike which the latter has would bring it to the position occupied by the former.

Just west of the junction of the stream G, with the Ramtek river, there is an outcrop of good coal (pit 55) about 14 feet in thickness, resting upon thin, splintery carbonaceous shales, with interbedded thin seams of coal, dipping N. 45°. The seam

was traced for a short distance westward. Higher up the stream G, north of pit 69, there is a thin seam of good coal (3′ 6″) resting upon shales, and dipping about 50° N.—6—W.

By the stream H, and the footpath just east of it, there are indications of several promising seams. But the ground is so extremely covered up that they could not be traced far on either side of it. The section by the stream exposed by a cross cut, pit 85 (*i.e.*, a trench across strike), is as follows (in descending order):—

a. 10′ *coal*, dip 45°.
27′ sandstones.
8′ black carbonaceous shales.
b. 4′ good *coal*. }
8′ shales. } Dip 45° N. to N.—10—W.
c. 11′ good *coal*. }
Shales.
80′ shales, sandstones, and coal, not well exposed.
d. 11′ *coal*.

From the steadiness of the strike between the streams G and H, I have but little doubt that the seams *b* and *c* of the above sections with some of the associated carbonaceous shales represent the thick seam of pit 69; and that the seam *a* represents the thin seam above pit 69, though the former is immensely thicker than the latter.

At pit 99 by the footpath just east of the stream H, a good seam about 8 feet thick is exposed, which I am inclined to connect with the coal of pit 100 presently to be mentioned.

The strike continues very steady for some distance westward. By the footpath just east of the stream C, there are several exposures of good coal. At pit No. 90, we have the following section:—

9′ *coal*.
1′ shales.
2′ *coal*.

Below pit 90 occur shales with thin seams of coal until we come to pit 100, where there is a rather promising seam of which the exposed thickness is no less than 10 feet. I am inclined to consider the latter as identical with the coal of pit 99 east of the stream H.

With regard to the coal of pit 90, it very likely represents the seam *d* of the section at pit 85. The higher seams of this section are, I believe, caught in pit 79 further west by a footpath east of the stream B. Here the section is as follows (in descending order):—

97′ reddish sandy shales with thin *coal*.
a. 19′ *coal*.
4′ shales.
b. 28′ good *coal*.
Hard reddish shales.

The dip varies in amount from 35° to 55°, and in direction from N. to N.N.W. The thickness of the seam *b* in this section, taking the average dip at 45°, is

found to be 19·8 feet. Together with seam *a* its thickness would be very nearly that of the thick seam of the stream G (pit 69), with which I am strongly inclined to identify it.

Proceeding further west along the strike, some seams were exposed by excavation by the stream A. None of them appears to be very promising, and if they represent any of the seams mentioned above (as from the strike they appear to do, at least in part), they must do so in a considerably attenuated form.

The Lisu Valley.

At the forest boundary dividing Chunkhola from the Lisu valley the ground is much covered up. The few outcrops seen here are all of worthless coal. West of the forest boundary, indications of good coal were found by the stream N. at pit 14 and the one above it. In the former, the seam is 7 feet thick, dipping N.—15—W., and in the latter, the seam is 7 feet 6 inches in thickness, dipping 35° N.—10—W. The strike of these as well as of the outcrops at pits 15 and 16, is the same as that prevailing east of the forest boundary in pits 70, 74, &c.

Further west, the strike changes probably by a twist, the dip in the pits 4, 82, 17, and 18 west of the stream R being north-eastern The section exposed by pit 4 is as follows (in descending order) :—

Carbonaceous shales with thin seams of coal.
4' *coal.*
1' carbonaceous shales. } Dip 25° E.N.E.
4' *coal.*
Sandstones.

The seam exposed by pit 18 is 5 feet 6 inches in thickness: and the coal appears to be very good. The seams in pits 17 and 82 were not well exposed ; and their thickness is doubtful. From the strike it seems to me probable that the coal of the pits 4, 82, 17, and 18 represents respectively that of the pits [illegible], 107, 15, and 16.

Further west, the ground is so covered up by detritus from the Dalings, that very little rock is seen *in situ*. There are, however, indications of excellent coal in pits 1, 2, and 3. The section exposed by pit 1 (in descending order) is as follows :—

a.—5' 9" good *coal.*
3' 3" black carbonaceous shales.
4' sandstone.
5' black carbonaceous shales.
b.—1' 10" *coal.*
5' 3" black carbonaceous shale.

The dip is high about 65° to 80°, pointing E. to E.N.E. The seam *a* was traced for some 100 feet northward, where a fault appears to separate it from the seams of pits 2 and 3. In pit 2, a seam of excellent coal, 3 feet 6 inches in thickness, is observed interbedded with micaceous, sandy shales, which yielded a large number of fairly-preserved fossils mostly belonging, however, to one genus, *Vertebraria.* The seam in pit 3 is about 2 feet 9 inches in thickness ; it is very likely identical with that of pit 2. The dip of both is high (about 50°) N. W. to N.N.W.

Tabular Summary.

The following is a tabular summary of the principal coal-seams not less than 5 feet in thickness, leaving out those which have been too highly altered by contact with igneous rocks:—

Seam (indicated by pits)	Dip.	Average thickness in feet	Length of seam actually traced in feet.	REMARKS.
(I)—SUPERIOR COAL (CLASSES A AND B)[1]				
I.—Churanthi and Ramthi Valleys				
(1) 39—41—42—43—60—75—6—38—51	40° to 55° N E. to N.W	22	800	This seam is very likely continued to next pit under Tertiary conglomeratic sandstones which cover the intervening ground
(2) Near pit 95 (close to junction of stream M with the Churanthi) . .	N N E	?	...	This coal is probably continued to next pit.
(3) 93	50° N.	17·5		Part of this coal is of inferior quality This seam is possibly continued to seam 4
(3a) 91	45° N—10—E	6	.	Probably identical with seam (5 b)
(4) 33—(Stream P, a feeder of the Ramthi) .	70° W	9 4		
(5) 7—(Two seams faulted) .	70°N N E to N E (16 feet seam) S W (6 feet seam)	22 (total thickness)	200	Very likely continued to near pit 95.
(5a) 104—46—28—105 . .	45 N W to N N E	5 ?	1,650	
(5b) 47—48—49 . . .	35° to 50° N to N N E.	8 5	825	
II.—Chunkhola				
(6) 65—(Upper seam) .	30° E N E	13 5	340	These seams are possibly identical with those next named
(7) 65—(Lower seam) .	50 E N.E	22 8		
(8) 25 . . .	50° N	30 ?	..	This is probably identical with lower seam of next pit.
(9) 36 (Upper seam) . .	40° N 10 E to N 10 W	15	300	
(10) 36 (Lower seam)	45° N	20		
(11) 56—35	50° E S E to 55 E N E	18 5	55	This seam is faulted against the one next named.
(12) 35 . . .	E S E	13	250	
(13) 5 . . .	E. 10 N.	14	165	Possibly identical with the next seam, but shifted by a fault.
(14) 29 . .	45° E. N. E.	12	660 ?	Probably continued to next seam. The thickness given here is the aggregate thickness of two seams parted by 9 inches of shales.
(15) 59—69—85—79 (?) .	45° to 65° N to N N W	27 (?)	1,815	
(16) 101 (Stream G, above 69)—85 (uppermost seam)	45° to 50° N. to N. N W.	5 ?	500	

[1] *Vide infra*, pp. 17—18.

Seam (indicated by pits).	Dip.	Average thickness in feet.	Length of seam actually traced in feet.	REMARKS.
(17) 34—68—53—55—64—102	45° N. N. E. to N.N.W.	8	1,000	
(18) 99—100. . . .	45° N.N.E. to N.N.W.	9	700	
III.—Lisu Valley.				
(19) 14—4	35° N. 10 W. to 25° E.N.E.	5·25	750(?)	
(20) 1	65° to 80° E. to E.N.E.	5·5	...	
(II)—INFERIOR COAL (CLASS C).[1]				
I.—Churanthi and Ramthi Valley.				
(21) 8—21—9—10—40—45—27—103 . . .	50° to 85° N.W. N.N.F. N. 10 E.	15 ?	1,800	The seam is very thick between pits 40 and 45. It is very likely continued to next pit.
(22) 97 (Nunmati stream) .	N.N.W.	...	...	Seam of 32 is probably identical with the upper one of 30.
(23) 32	W.	7	.	
(24) 30 (Two seams) . .	W.	13 (total thickness).	...	
II.—Chunkhola.				
(25) 11—45	N.N.W.	8	..	

§ 2. *Quality of the Coal*

With regard to quality, the coal may be classed under three heads as follows:[2]—

Class A.—Cakes strongly. Percentage of ash not exceeding 16.

	Pit No 3 (Lisu Valley).		Pit No. 1 (Lisu Valley).	Pit No. 1.
Moisture	14 54	Percentage minus the moisture.	4 72	3·28
Volatile matter (exclusive of moisture)	8 86	10 37	22·16	20·60
Fixed carbon	63 96	74·84	60 24	60 12
Ash	12 64	14 79	12 88	16·00
Colour of ash	Gray. Cakes strongly, and forms a light tumid cake.			

Three samples from pits Nos. 1, 2, 3 in the Lisu valley were found to contain respectively 10·64, 8 88, and 16·12 percentage of ash. These samples as well as those from pit No. 1, of which the analyses are given above, were from the surface, and were found either not to cake or only to nter slightly. From a depth of 5 or 6 feet from the surface, the coal from all these pits was found to coke strongly, like the sample from pit No. 3, the analysis of which is given above.

As far as I could judge from appearance, the coal from pits Nos. 29, 59, and 69 belongs to this class.

From the analyses given above, the average percentage of ash is found to be 12·23, and the average percentage of fixed carbon, 61·44.

[1] *Vide, infra*, p. 19.
[2] The analyses were made in the Survey Laboratory.

Class B.—Cakes strongly. Percentage of ash between 16 and 22.

	Pit No. 7, Churanthi Valley, depth 9 feet.		Pit No 25, Chunkhola or Ramtek River, depth 7 feet.		Pit No. 7, Churanthi Valley, surface.	Pit No. 7, surface.	Pit No. 7, surface.	REMARKS.
Moisture	4 21	Percentage minus the moisture.	16 10	Percentage minus the moisture.	20 80	21·48	17 20	From a comparison of the analyses of the different samples from pit No. 7, the caking power is found to increase, and the percentage of ash to decrease, with depth.
Volatile matter (exclusive of moisture).	14·09	14 71	15·47	18·44				
Fixed carbon	62·56	65·31	51·85	61·80	57·92	56 52	63 28	
Ash	19·14	19 98	16·58	19 76	21·28	22 00	19 52	
	100 00.	100 00	100 00	100 00	100·00	100 00	100 00	
Colour of ash	Pale brown . .		Reddish gray . .		Dark red .	Dark red .	Dark red .	
	Cakes strongly .		Cakes strongly .		Cakes, but not very strongly.	Sinters slightly.	Cakes, but not very strongly	

The coal of the pits 39, 41, 42, 43, 6, 38, 65, 36, 35, 56, 13, 55, 100, &c., in fact the greater portion of the coal described above, appears to belong to this class.

Class C. Does not cake. Percentage of ash between 22 and 33.

	Pit 30, Ramthi Valley (Surface)	Pit 30, Ramthi Valley. (Surface)	Pit 9, Churanthi Valley.
Moisture	·80	1·60	5·76
Volatile matter, exclusive of moisture	7·88	10·40	
Fixed carbon	58·12	61·76	69·84
Ash	33·20	26·24	24·40
	100·00	100·00	100·00
Colour of ash	Dark brown.	Light red	Dark brown.

To this class belongs the coal of pits 8, 21, 10 45, 40, 27, 103, in the Churanthi valley, 97, 32 in the Ramthi valley; 11, 12, 54 in the Chunkhola.

In the following table the Darjiling coal (Class A and B) is compared with the Raniganj coal:—

	Fixed carbon.	Volatile matter (including moisture).	Ash.
Darjiling, average of 8 assays	59·56	22·94	17·42
Raniganj, average of 31 assays	53·2	30·63	16·17

The utilisation of the Darjiling coal depending to a great extent upon its caking property, care was taken to test it in the field in earthen *kalsis*, as well as on a larger scale in kilns. Three kilns were put up, one on the saddle separating the Churanthi valley from the Chunkhola, another in the Chunkhola, and the third in the Leeshkhola (Lisu valley). Coal from pit 7 was tried in the first, from pit 25 in the second, and from pits 1 and 3 in the third. All of the kilns turned out good coke which has been pronounced by a competent authority to be quite up to any made at Barakar. A sample of the coke assayed in the Survey Laboratory was found to contain only 0·62 per cent. of sulphur (0·58 per cent as sulphide, and 0·04 per cent. as sulphate).

The fact that so many of the outcrops have yielded good coke is the most hopeful feature about the explored coal

§ 3. *Quantity of immediately available good coal in the central portion of the explored area.*

With regard to the quantity of the coal, I shall attempt a calculation of it only for the central portion of the explored area (marked *a*, *b*, *c*, *d* on map), which was

opened up in greater detail than any other portion. This area measures only 97 acres, or about three-twentieth of a square mile. Within this small area, I shall, to be on the safe side, restrict myself to those seams or portions of seams which have been actually traced by me. Further, I shall neglect all coal which contains more than 22 per cent. of ash, and all seams less than 5 feet in thickness.

I shall put the limit of workable depth at 1,000 feet. In Europe there are coal mines of more than treble this depth in rocks quite as highly disturbed as those we are dealing with. But, in India, no coal mine has, I believe, yet reached the depth of 500 feet; and in taking the limit of workable depth at a thousand feet, I hope I am not transgressing the bounds of Indian probabilities.

For facility of calculation, I shall assume an uniform average inclination of 45° for all the seams. From an inspection of the table of principal seams, it will be seen that this average is well warranted by facts.

Seam.	Available quantity of coal in tons.
(1)[1]	746,592
(5)	186,648
(5a)	349,965
(5b)	279,972
(6)—(7)	519,214
(8)—(10)	509,040
(11)—(12)	328,755
(13)—(15)	1,903,809
(16)	106,050
(17)	395,354
(18)	267,246
	5,592,645

In round numbers we have 5½ millions of tons of almost immediately available good coal belonging to classes A and B within an area of not more than 97 acres. The whole of this coal will, I believe, be found to be convertible into good coke. For the entire explored area, which measures a little over one square mile, the amount must be much greater though not proportionately, as the seams appear to suffer attenuation eastward as well as westward. Twenty millions will not, I think, be an over-estimate for the whole of the explored area. If we take coal of class C into account, we would probably have some ten millions of tons more.

§ 4.—*Carriage; mineral resources; labour; mining.*

Carriage.

The coal-field is situated at a distance of 2½ miles (as the crow flies) from the Duars. There is only one made road in the explored area, the Kalimpong-Bagrakot road. It passes along the water-shed between the Lisu and the Churanthi and is practicable for ponies. Running as it does through the central and apparently the richest portion of the coal-field, its importance, if widened into a cart-road, would be great. There is a path which runs along the Lisu river to Asabari at the foot of the hills, where a *hât* is held every Sunday. It could be made into a cart-road; but the expense will, I think, be greater than in the case of the Kalimpong-Bagrakot road, as several bridges will be required.

[1] These numbers refer to the seams tabulated before, see pp. 16—17. Strike faults may reduce the estimated quantity to some extent.

From the foot of the hills there is a cart-road to Silliguri, a distance of about 18 miles. The only river it crosses is the Tístá. At present tea from the plantations just at the foot of the hills is carried to Silliguri at a charge of about 5 annas or so per maund. If the cart-road be extended to the coal-field, carriage by cart to Silliguri would cost 6 annas per maund. If a tramway be made, the cost would be much reduced.[1] The proposed Duars Tramway will pass at a distance of about 10 miles from the coal-field, and a branch to it is well worth the consideration of the Tramway Company. Besides the coal, the branch line would tap several flourishing tea plantations, such as Bagrakot, Phulbari, and Asabari. I must say, however, that traffic on this line would have to be suspended for three months and a half, from June to the middle of September; for the rivers which the proposed branch line would cross swell to large proportions during the rains, though almost dry for the remainder of the year.

Mineral resources in the vicinity of the coal.

With regard to mineral resources, the coal-field is advantageously situated. Seven miles to the north of it, at the head of the Rere Ung, there are some excellent iron-ores.[2] There are two kinds of ore, of which one is described by Mr. Mallet to be in places pure magnetite, but more usually including a varying proportion of actinolite; the other is a "schist composed of magnetite, micaceous hematite, actinolite, and talc, irregularly interbanded; the last three also including octahedrons of magnetite." Specimens of both kinds of ore have been assayed with the following results:—

	Percentage of iron.
Magnetite	71·50
Micaceous hematite	59·89

Neither contain any phosphorus or sulphur.

Mr. Mallet who examined the ores observes: "the deposit is a valuable one; as will have been seen from the assays, the ore is extremely rich, and the quantity appears to be considerable, while the iron produced is of the best quality."

There is copper ore two miles north-west of the coal-field on Yongri Hill. Mr. Mallet who examined it in 1882 observes:[3]

" . . . . The Yongri seam, like all the other known cupriferous seams in the Darjiling district, (1stly) occurs in the rocks of the Daling series, (2ndly) is a bed, not a true lode, and (3rdly) that the ore is copper pyrites.

"As is commonly the case in the Darjiling mines, the seam is not of constant thickness, expanding in some places, as I was informed by the miners, to a foot or so, and in others thinning to only 1 or 2 inches. A sample of the ore, as it was being brought out from the mine, yielded on assay 1·5 per cent. of copper, while a sample of picked ore gave 0·6 per cent.

* * * * * *

"Taking the general strike of the rocks into account, it is not impossible, perhaps not improbable, that the Yongri cupriferous band is on the same horizon as the metalliferous strata at Mangphu. The chance is at least sufficiently great to suggest a somewhat promising clue towards the discovery of new outcrops, between the two positions, to any one with sufficient geological knowledge to apprehend the bearing of the facts."

[1] Carriage by the Tístá to Jalpiguri, if practicable, would be cheap. I hear tea from some of the plantations near the coal-field is conveyed in boats down this river. The coal could be carried down to the foot of the hills by wire-tramway; and this mode of conveyance may prove cheaper than an ordinary tramway.

[2] *Vide* Mem., XI, p. 67.

[3] Rec., XV, pp. 56—57.

[The Mangphu copper ore on the Tístá, referred to in the above extract, is not very far from the coal-field, about 6 miles to the north-west.]

A mile and a half north-east from the Yongri mine, on the western flank of Sampthar hill, Mr. Mallet encountered a metalliferous band, which was found to contain "arsenical pyrites with a somewhat considerable proportion of mundic and a little copper pyrites." "As white arsenic and orpiment (arsenious acid and arsenious sulphide)," says Mr. Mallet, "are both easily prepared from arsenical pyrites, and orpiment is used to a considerable extent in India in connection with the preparation of hides, it seems likely that if some of the copper miners were to learn the way of making the above-mentioned products, they could profitably work the Sampthar ore, especially as some copper could be subsequently extracted from the spent pyrites."[1]

There are deposits of tufaceous limestone in the Chunkhola, from which lime used to be made at one time. But the supply from this source will never be plentiful; it will certainly not meet the demand for the manufacture of iron on a large scale. There are beds of limestone belonging to the Daling series in the Chunkhola; but the limestone appears to be poor.[2] I could, however, but pay little attention to it. Very likely with closer search more promising outcrops will be found. We have good coke, and an abundance of rich iron-ores: with good flux, we may expect to have iron manufactories at no distant date in the Darjiling District.

Labour-supply.

There are a few villages north and north-west of the coal-field. But they are scantily populated; and land is so cheap that every tenant has got more of it than he can well attend to. Consequently labourers as a class do not exist; and great difficulty was felt by me in procuring local labour. If the coal be worked, Nepalese labourers will have to be got. In the neighbouring cinchona plantation at Nimbang they work at R5-8 to R4 per month; and there is no reason why they should not be available for the coal mines at the same wages, *provided that suitable land for them to settle on be found.* Every family of labourers requires a small plot of land to grow *bhutta* on; in fact, the low wages mentioned above are conditional upon such land being granted rent-free. Within the coal area, there are not many good sites for settlements; and should the coal be worked on an extensive scale, a fringe of cultivable land to the north and west of the coal-field at Chankiang and Makum would be required.

Mining.

With regard to mining, some of the conditions appear to be distinctly in favour of the coal, while others are quite as distinctly against it. The disturbance which the coal and associated rocks have suffered is by no means an unmixed evil. Owing to its crushed condition it can be easily dug out with picks and *kodalis*, so that the cost of extraction would be much less than in the Raniganj and Giridih mines. On account of its high dip, the Darjiling coal has been brought to the surface; consequently, it will not, as a rule, be necessary to sink shafts through unproductive rocks, and a very heavy item of expense will thus be saved. The powdery condition of the coal is favourable for coke-making; and water for the kilns or ovens could be brought down from a higher level than these in bamboo or iron pipes at a comparatively trifling cost. On the other hand, owing to the crushing which the coal and the associated rocks have undergone, these (especially the shales) are not likely to afford a firm roof in deep mining, and extensive timbering will be necessary. There being reserved forest, however, on all sides, timber will be cheap.

[1] *Op. cit.*, p. 58

[2] *Vide ante*, p. 8.

The Basic Eruptive Rocks *of the* Kadapah Area, *by* PHILIP LAKE, B.A., F.G.S., *Geological Survey of India.*

In Southern India there were at least two great periods of eruption of basic rock before the time of the Deccan trap. The first eruption took place in the Dharwar and the second in the Kadapah epoch. Before Dharwar times, and also between the Dharwar and Kadapah epochs, there were many dykes injected into the crystalline and schistose rocks of the country, but they are at present unconnected with any contemporaneous flows, and may never have reached the surface.

The contemporaneous traps of the Kadapahs are all found in the Poolumpett beds of the Cheyair group. In the rocks below these there are many intrusive dykes but no flows, while above the Cheyair group no traps of any kind are found among the Kadapah rocks. A full account of the relations of these traps to the beds in which they occur is given by Dr. King in his Memoir on the Kadapah and Karnul rocks.[1]

The chief of the contemporaneous flows are those of Jootoor and Palamodu.

Adopting Mr. Teall's classification,[2] the Jootoor trap is an olivine-dolerite, or olivine-gabbro. It is a fine-grained holocrystalline rock composed chiefly of olivine, augite, and plagioclase felspar, but containing also "opacite" (probably magnetite) and a little mica. The specific gravity is 2·9, and the percentage of silica is 45·59.

Jootoor trap.[3]

The olivine, which seems to have crystallised out before the augite and felspar, occurs in rounded grains, which are frequently clouded at the edges. Along the cleavage cracks opacite has been developed in great quantity, but there is no sign of alteration into serpentine. The olivine granules are sometimes included in the augite and felspar.

The augite generally forms large ophitic masses, but occasionally occurs in fairly well-defined prisms. It is of a very pale brown colour. The cleavage is generally irregular. One section of a twinned prism which shows the prismatic cleavages, making an angle of 89° with each other, also shows a striation parallel to the trace of the twin-plane, *i.e.*, to the orthopinacoid (100). In this it resembles diallage, but the striation is not very marked. Opacite is developed along this lamination, and also along irregular cracks which cross most of the sections of augite.

The felspar is not abundant, and there are not enough crystals for the determination of the species. It is twinned on the albite plan.

A little brown dichroic mica is also found. Opacite is sometimes developed along its cleavage planes.

The opacite, as already mentioned, occurs along the cracks and cleavage planes of the ferro-magnesian constituents, especially the olivine. It is mostly in the form of a fine dust, but occasionally forms little needle-shaped crystallites. It is probably magnetite, and has evidently been formed by the alteration of the olivine, &c.

Greenish chloritic matter also occurs in the rock, but is not abundant.

[1] King. Mem. G. S. of I., VIII.—The specimens on which the descriptions in this paper are based were collected by Dr. King, and are now in the Indian Museum.

[2] British Petrography, p. 70.

[3] Mem. G. S. of I., VIII, p. 196.

Palamodu trap.[1]

The Palamodu trap is a dolerite without olivine. It consists chiefly of augite in an earthy base. The base has evidently been formed by the alteration of felspar, and remnants of plagioclase crystals are seen in it. Besides the augite, there is also a serpentinous mineral which seems to have been formed by the alteration of the augite. The specific gravity of the rock is 2·9.

The augite occurs in crystalline masses without crystalline outlines. Very often the plagioclase crystals, or the earthy pseudomorphs of these, penetrate the augite, and it is clear that the augite crystallised out after the felspar. The rock is, therefore, ophitic (diabasisch-körnig of Rosenbusch). Besides the prismatic cleavages, there are shown in some of the augite sections sets of dark lines parallel to the planes, 100 and 010. These are not always easily distinguished from the prismatic cleavage; but in one section which shows the two sets of dark lines at right angles to each other (and in convergent polarised light gives an optic axis a little outside of the field), the extinction is parallel to these lines, and the lines are therefore not parallel to the prism (110). The development of planes parallel to the pinacoids suggests that the augite may be rhombic; but this is not the case. In sections out of the zone 100,010 (with the cleavages parallel) the extinction is not always parallel to the cleavage; and when it is parallel, the section shows an optic axis in convergent polarised light. The augite is therefore monoclinic. Its double refraction is positive and strong.

It is probable that the dark lines are generally developed, parallel to only one of the planes 100, 010; for in most of the sections only one set of these lines is visible.

The augite, separated as well as possible from the other components of the rock, was found by Behrens' microchemical methods to contain Ca, Mg. and some Al.[2] The amount of Al found was small, and it may have come from the other materials of the rock, which could hardly be completely separated from the augite. The augite is not highly aluminous.

In many cases the augite is partly altered into a fibrous-looking earthy substance, the fibres apparently lying nearly at right angles to the vertical axis.

The final product of alteration of the augite is a fibrous-looking mineral penetrated by little veins of what appears to be the same mineral oriented differently. The colour is greenish yellow, and the mineral shows a feeble pleochroism. The extinction is parallel to the fibres or cleavage. In convergent polarised light, the mineral is found to be bi-axial; and as the extinction is straight, it must be rhombic. It is probably bastite.

The felspar is almost entirely decomposed, and the species cannot be determined. There are besides the plagioclase, a few grains of clear felspar without any definite form and without any twining. This is probably of secondary origin. There is also a little quartz, which may have been set free during the alteration of the felspar.

[1] Mem. G. S. of I., VIII, p. 198.

[2] Being unable to procure any cæsium chloride, I was obliged to use rubidium chloride instead as a test for Al. For suggesting the use of rubidium chloride I am indebted to Mr. P. Bruhl of the Civil Engineering College, who kindly gave me a specimen. 100 parts of water at 17° dissolve 0·619 parts of cæsium alum or 2·27 parts of rubidium alum (Watt's *Dictionary of Chemistry*, after Redtenbacher), so that the test with cæsium is about 3·7 times as delicate as that with rubidium. With cæsium 0·01 milligrammes of Al_2O_3 can be clearly proved, and therefore with rubidium 0·37 milligrammes can be detected. In the present case the drop of liquid was allowed to evaporate slowly, almost to dryness.

At Betumcheru, in Karnul District, is another mass of trap, which also appears to be contemporaneous and of Poolumpett age. This rock is composed chiefly of plagioclase and augite. There are two specimens in the Museum, one obtained at Betumcheru, and the other three miles W. S. W. of Betumcheru. The former is fine-grained and holocrystalline (Sp. gr. 3·0), while the latter is compact and contains amygdaloids (Sp. gr. 2·7).

Betumcheru trap.

In the first specimen the augite very much resembles that of the Jootoor trap. It has crystallised after the felspar, and forms ophitic plates. The felspar crystals frequently penetrate it. It is often partly decomposed into a clouded greenish substance which is dichroic.

The plagioclase occurs in long lath-shaped sections with numerous twin-lamellæ. The maximum extinction found in the zone 100,001, referred to the trace of the plane 010, was about 29°, and the plagioclose is therefore labradorite, or possibly a more basic felspar.

Magnetite is scattered through the rock in nests.

The second specimen (3m. W. S. W. of Betumcheru) is very finely crystalline. Almost all the augite appears to have been converted into chlorite, and the rock is practically composed of plagioclose microliths in a chloritic base. Magnetite is scattered through the rock in small grains and in skeleton crystals. A few grains of a brownish granular substance fill up the interstices of the rock, and there is also a little hæmatite present.

The amygdaloids are composed of quartz, or quartz and chalcedony, in alternate layers. In some cases chlorite fills up the spaces between the quartz crystals.

From these descriptions it will be seen that the Kadapah traps are essentially plagioclase-augite rocks. The Jootoor trap contains olivine, and in parts of the Betumcheru mass the augite has been converted into chloritic or, possibly, serpentinous matter. But this does not alter the character of the rock.

The augite appears to be non-aluminous or but slightly aluminous, and is allied to diallage. The felspar is basic, and in parts of the Betumcheru trap, and probably in the other traps also, is allied to labradorite or bytownite.

The occurrence of these highly magnesian traps in the Kadapahs is interesting in connection with the presence of serpentinous and steatitic rocks in the Paupugnee beds, which lie below the horizon of the contemporaneous traps. Dr. King[1] shows that where the Paupugnee limestones and slates are in contact with trap, they are frequently seamed and veined with serpentine. Steatite also is abundant in places. The Paupugnee traps are intrusive, and there can be little doubt that they are of the same age and character as the Cheyair traps; and the serpentine and steatite are evidently derived from the augite and olivine forming so large a part of them.

The Deep Boring at Lucknow, *by* R. D. OLDHAM, A.R.S.M., *Deputy Superintendent, Geological Survey of India.*

An experiment of considerable practical and scientific importance has lately been carried out by the Municipality of Lucknow, which has put down a boring, 1,300 feet in depth, in search of an artesian water-supply. A section of this boring, received from the President of the Municipal Board, is here published and deserves some comment.

[1] *Loc. cit.*, pp 164—166.

Our late Director, Mr. H. B. Medlicott, always maintained that artesian water could be obtained by deep borings in the Gangetic plains, the failure of those put down as yet being due to their unfavourable situation. Though it is extremely improbable that the Gangetic alluvium has that structure which would have been most favourable for the production of an abundant supply of artesian water, and was at one time believed by Mr. Medlicott to be the actual structure, yet it has been recognized that the analogy of previous experience in other alluvial plains justified the hope that water would be obtained under sufficient pressure to rise to the surface; the only difference of opinion being as to the probable abundance of the supply.

It will be seen from the record that, as the boring progressed, water steadily rose in the bore hole till, between 1,189 and 1,202 feet, a bed of quicksand was passed through, from which 10 gallons per minute flowed from the top of the bore hole This is of course a miserable supply to be obtained from so expensive a venture, but does not by any means represent the true capacity of the bed, owing to the want of judgment shown in the selection of the points at which the size of the casing was reduced. I find that the bottom of the 12″ pipe is at 408′ 8″ in "fine sandy silt;" of the 10″ pipe at 798′ 1″ in "quicksand with abundance of mica," and the 8″ pipe ends at 898′ in "kankar, hard, with a little sand." All these are permeable beds, one freely so, in which the water had not sufficient pressure to rise to the surface; at all these junctions there must have been leakage, and the 10 gallons a minute, barely flowing at the surface, do not truly represent either the pressure or the discharge of the 4″ pipe at the bottom of the well.

In the current newspapers this boring has been stigmatised as a failure; such it doubtless is if regarded as a source of water-supply, but as an experiment it has been conspicuously successful. It has established the fact that at 1,200 feet there is water under sufficient pressure to flow at the surface; it is probable the succeeding water-bearing strata, which would be struck by a deeper well, would yield water at a higher pressure; and, even if the pressure and supply so obtained be insufficient, an abundant supply of pure water will be obtainable by pumping.

In sinking a fresh well, as has been decided on, it will be necessary to start with a larger size of bore hole, and to show greater judgment in selecting the points at which the casing is reduced in size. The boring just abandoned appears to have been made with an ordinary chisel bit, and the casing driven close behind the head of the boring till it would go no further; but, in such stuff as was passed through, there seems no reason why an expanding bit should not be used, thereby reducing the friction against the outside of the casing and increasing the distance to which each separate size could be driven.

There are two points of theoretical interest connected with this boring. They are (1) whether the head of water comes from the northern or southern margin of the plains, and (2) whether the bore hole has not nearly reached the base of the alluvium.

With reference to the first. It has now been established that the formation of the depression, now occupied by the Gangetic alluvium, has proceeded *pari passu* with the elevation of the Himalayas, and that it has extended southwards by the gradual subsidence of the northern limit of the peninsula rock area. On its northern boundary the history has been different: the deposits formed at the foot of the Himalayas during the Siwalik period, which were originally part of the Gangetic plain, have been compressed, elevated and cut off from their continuation under the,

at present, undisturbed deposits at the foot of the hills. There is consequently no reason for supposing that the gravel and sand deposits of the *bhábar* continue under the alluvium; on the contrary, there is every reason to suppose that they have been deposited over a comparatively impervious deposit of clay and silt with occasional beds of sand. Yet, owing to the want of continuity of individual beds, their lenticular shape and their great horizontal extension as compared with their vertical thickness, it is possible that the water would find an easier, if tortuous, underground passage in a direction parallel to the bedding than transverse to it, and so the head might be derived from the northern margin of the plains.

On the other hand, the manner of the southward extension of the alluvium through subsidence of the surface would lead to the formation of a zone of coarse-grained sand, and possibly gravel deposits, overlaid by finer-grained impervious clays. This structure would be particularly favourable for artesian conditions, although the elevation of the southern margin of the plains is much less than that of the northern.

As things stand then, we have a greater effective head to the north, but a more tortuous passage for the underground water, and consequently a greater loss of head; to the south the effective head is less, but, if the bore hole has reached nearly to the base of the alluvium, a more direct passage for the water and less loss of head by friction. The single boring put down is insufficient to decide between these two alternatives.

As regards the second point, whether there is any great thickness of alluvium below the bottom of the bore hole, this may be decided by the next boring, which, it is to be hoped, will be carried to a greater depth than the present one. At present the question is more or less one of conjecture, but the frequent reference to "coarse sand," in the lower part of the boring, points to a closer proximity of the margin of the alluvium than is at present the case, and consequently to an approach to the base of the alluvium. If my supposition is correct, the total thickness of the alluvium under Lucknow would not be more than 2,000 feet at the outside, and probably some hundreds less than this.

Record of the Lucknow Artesian Well.

DESCRIPTION OF SOIL	Colour.	Thickness of stratum.	Total depth.
Made earth, Old Fort embankment	Brown	24	24
Sandy clay	Yellowish brown	17½	41½
Kankar, mixed with clay	Bluish gray	6½	48
Sand and clay, alternate thin layers	Brown	2	50
Quicksand, micaceous	Gray	14	64
Sandy clay	Brown	2	66
Clay, with a little fine sand	Yellow	19	85
Sand, with a very little clay	Gray	5	90
Quicksand, fine	Yellow	14	104
Clay	Whitish	5	109
Clay, with scattering kankar nodules	Bluish brown	7	116
Kankar	Bluish gray	6½	116½
Sandy clay	Yellow	1½	118
Kankar and clay, mixed	Bluish gray	1	119
Sandy clay	Yellowish	2	121

Record of the Lucknow Artesian Well—continued.

Description of soil.		Colour.	Thickness of stratum	Total depth.
Sand, clean		Gray	3	124
Sandy clay		Brown	24	148
Quicksand		Gray	4	152
Silt, fine		Yellowish brown	6	158
Quicksand, fine	*water 61 ft.*	Yellowish brown	5	163
Sand, with a little clay		Yellow	6	169
Clay and silt mixed		Yellow	9	178
Clay carrying abundance of nodules		Yellowish (light)	8	186
Sandy clay		Yellow	4	190
Quicksand, very fine	*water 42 ft.*	Yellowish (light)	6	196
Quicksand, coarse		Gray	13	209
Clay		Whitish	6	215
Silt, fine		Brown	4	219
Sand clay, hard		Brown	7	226
Clay and sand, mixed		Yellow	7	233
Sand, free and hard		Gray	4	237
Sand, with a little clay, soft		Brown	1	238
Sand, free and hard		Gray	1	239
Sand, soft		Gray	2	241
Sand, free and medium hard		Gray	1	242
Sand, quite hard		Gray	2	244
Sand, coarse and nearly as hard as rock		Gray	2	246
Sand, medium, hard		Gray	10	256
Sand, fine		Brown	6	262
Sand, medium, hard		Gray	5	267
Sand, soft		Brown	4	271
Clay and silt, fine		Light yellow	4	275
Sand, coarse and very hard		Gray	2	277
Sand, do. medium hard		Gray	2	279
Sand, coarse and hard		Gray	2	281
Sand, coarse, alternate hard and soft layers		Gray	9	290
Sand, carrying abundance of nodules, hard		Gray	21	311
Sand and silt, fine		Light yellow	8	319
Sand, medium, hard		Gray	3	322
Sand, very hard, coarse		Gray	9	331
Clay and silt, fine		Yellow	7	338
Sand, coarse		Gray	3	341
Sand, coarse	*water 24 ft.*	Yellow	17	358
Sand, hard		Gray	2	360
Sand with a little clay, fine		Yellow	5	365
Sand, hard		Gray	4	369
Silt, fine		Brown	4	373
Silt, fine, with occasional nodules		Brown	6	379
Sand, fine and hard		Gray	2	381
Sand, fine and medium hard		Gray	2	383
Silt, fine		Gray	21	404
Silt, with abundance of nodules		Gray	4	408
Sandy silt, fine		Yellow	2	410
Clayey silt, fine		Reddish brown	20	430
Clayey silt, fine		Yellow	32	462
Sand, coarse and hard		Gray	1	463
Sand, with a little clay, rather coarse		Gray	7	470
Sand, fine and very hard		Gray	2	472
Sand, fine and medium hard		Brown	8	480
Sand, coarse and medium hard		Brown	9	489
Silt, fine		Brown	2	491
Sand, hard		Gray	2	493

Record of the Lucknow Artesian Well—continued

DESCRIPTION OF SOIL.	Colour.	Thickness of stratum	Total depth.
Sand, with a little clay	Gray	9	502
Sand, very hard (like rock)	Gray	1	503
Sand, with occasional very hard thin layers	Gray	7	510
Sand, free and medium hard	Gray	6	516
Sand, fine and soft	Gray	3	519
Sand, medium hard, free	Gray	3	522
Sandy silt, fine	Yellow	14	536
Sand, fine and hard, with a little clay	Gray	12	548
Sand, fine and hard, free	Gray	36	584
Sand, medium hard, free	Yellow	9	593
Clayey silt, very fine	Light yellow	12	605
Sand, medium hard, free	Gray	4	609
Silt, fine and soft	Yellow	13	622
Sand, fine and hard	Brown	2	624
Sand, very hard, like rock	Brown	2	626
Sand, hard and free	Brown	14	640
Sand, medium hard, free	Brown	4	644
Sand, very hard, like rock	Brown	1	645
Sand, medium hard, free	Brown	18	663
Sand, micaceous, with kankar nodules	Yellow	8	671
Sand, fine and medium hard, free	Yellow	4	675
Sand, coarse with hard layers	Gray	8	683
Sand, coarse and very hard, like rock	Gray	2	685
Sand, extremely hard and fine, rock	Yellow	5	690
Sand, fine, with abundance of kankar	Brown	10	700
Sand, fine, with very many hard kankar nodules	Brown	10	710
Sand, rather coarse, medium hard, with some kankar	Brown	25	735
Sandy silt	Brown	15	750
Sand, medium hard, free. *water 13 ft.*	Yellow	17	767
Kankar hard	Bluish gray	1	768
Sand, with layers of kankar nodules	Yellow	[illegible]	778
Sandy silt, with abundance of mica	Gray	[illegible]	783
Sand, with occasional kankar nodules *water 9 ft*	Yellow	9	792
Quicksand, with abundance of mica	Gray	6	798
Kankar, hard, with a little sand	Light gray	6	804
Sand, softish and free	Gray	2	806
Sand, with abundance of nodules	Brown	8	814
Silt, very tenacious	Brown	8	822
Kankar, very hard	Bluish gray	1	823
Sand, softish, carrying some mica	Yellow	32	855
Clayey silt, very tenacious	Yellow	7	862
Kankar, hard, with thin streaks of sand	Bluish gray	3	865
Sand, hard, and free	Yellow	5	870
Sand, midium, hard	Yellow	7	877
Kankar, hard, with a little sand	Bluish gray	3	880
Sand, medium, hard, with streaks of silt	Yellow	14	894
Kankar, hard, with a little sand	Bluish gray	6	900
Sand, fine, medium hard, with a little silt and some nodules	Yellow	27	927
Kankar solid bed, hard as rock	Bluish gray	2	929
Sandy silt, very fine	Brown	7	936
Limestone, medium hard	Gray	5	941
Sand and limestone, alternate thin layers	Gray	6	947
Sandy silt, very fine	Yellow	13	960
Sand, coarse *water 2 ft*	Gray	15	975
Sand, coarse, abundance of kankar, some mica	Gray	15	990
Quicksand, coarse *water 5 ft*	Gray	27	1,017
Sand, coarse, abundance of kankar nodules	Gray	23	1,040
Sand, coarse and free *water 5 ft.*	Gray	15	1,055

Record of the Lucknow Artesian Well—concluded.

DESCRIPTION OF SOIL.	Colour.	Thickness of stratum.	Total depth.
Kankar, solid bed, very hard	Bluish gray	2	1,057
Limestone, soft, commonly called rotten limestone	Gray	7	1,264
Rotten limestone, frequent hard streaks, some nodules	Gray	16	1,080
Limey silt, *i.e.*, limey clay with a little fine sand	Yellowish brown	27	1,107
Kankar, solid bed, very hard	Bluish gray	2	1,109
Limey silt, with occasional hard nodules	Yellow	24	1,133
Limestone, medium, hard	Gray	2	1,135
Limey silt, alternate hard and soft thin layers	Yellow	3	1,138
Kankar, solid bed, very hard	Bluish gray	3	1,141
Limey silt, hard and soft layers, some nodules, *water 1½ ft*	Grayish brown	7	1,148
Limey silt, with occasional hard streaks	Yellow	13	1,161
Quicksand, coarse, with abundance of mica	Yellow	5	1,168*
Sand, coarse, medium hard, with nodules	Gray	23	1,189
Quicksand, coarse, with abundance of mica—*water, flowed 10 gals. per minute at surface*	Gray	13	1,202
Sand, coarse, in hard and soft layers	Gray	19	1,221
Sand, fine, rather hard, with streaks of silt	Brown	19	1,240
Clayey silt, very fine, compact and uniform	Grayish brown	96	1,336

C. A. B. OLIVER,
Secretary, Municipal Board,
LUCKNOW.

* Sic in origin.

SUPPLEMENTARY NOTE.

Since the above article was sent to press, I have had an opportunity of visiting the works at Lucknow. No decision has been come to as yet about making a second boring; but the fact of a sheet of rising water having been struck certainly warrants a second and deeper trial, if only on the general ground of its possibly placing the province in a more hopeful condition of tapping water at places within an ascertainable range of the Lucknow level, or in the lower extent of the Gangetic plain. The cutting of the strata in the bore hole was so severe that the samples brought up have been reduced to great fineness; but it does not seem that any very coarse sands were met with: and thus it is not at all clear that the boring has touched anything like the lowest beds of the Gangetic alluvium.

Mr. Trowbridge, the Engineer in charge of the well-works, has explained away Mr. Oldham's doubts as to the proper enlargement of the hole at foot of tube; and apparent want of judgment in selecting points for insertion of tubes of decreasing diameter. There is a steel cutting shoe at the foot of the tubing which is quite powerful enough to cut out space for the descent of tube; while the larger tubes or drive pipes having been driven as far as possible, insertion of smaller tubing became necessary when the usual precautions as to sufficiency of overlap were observed, simple enough problems in well-boring, with so certified and experienced a specialist as Mr. Trowbridge.—*Editor.*

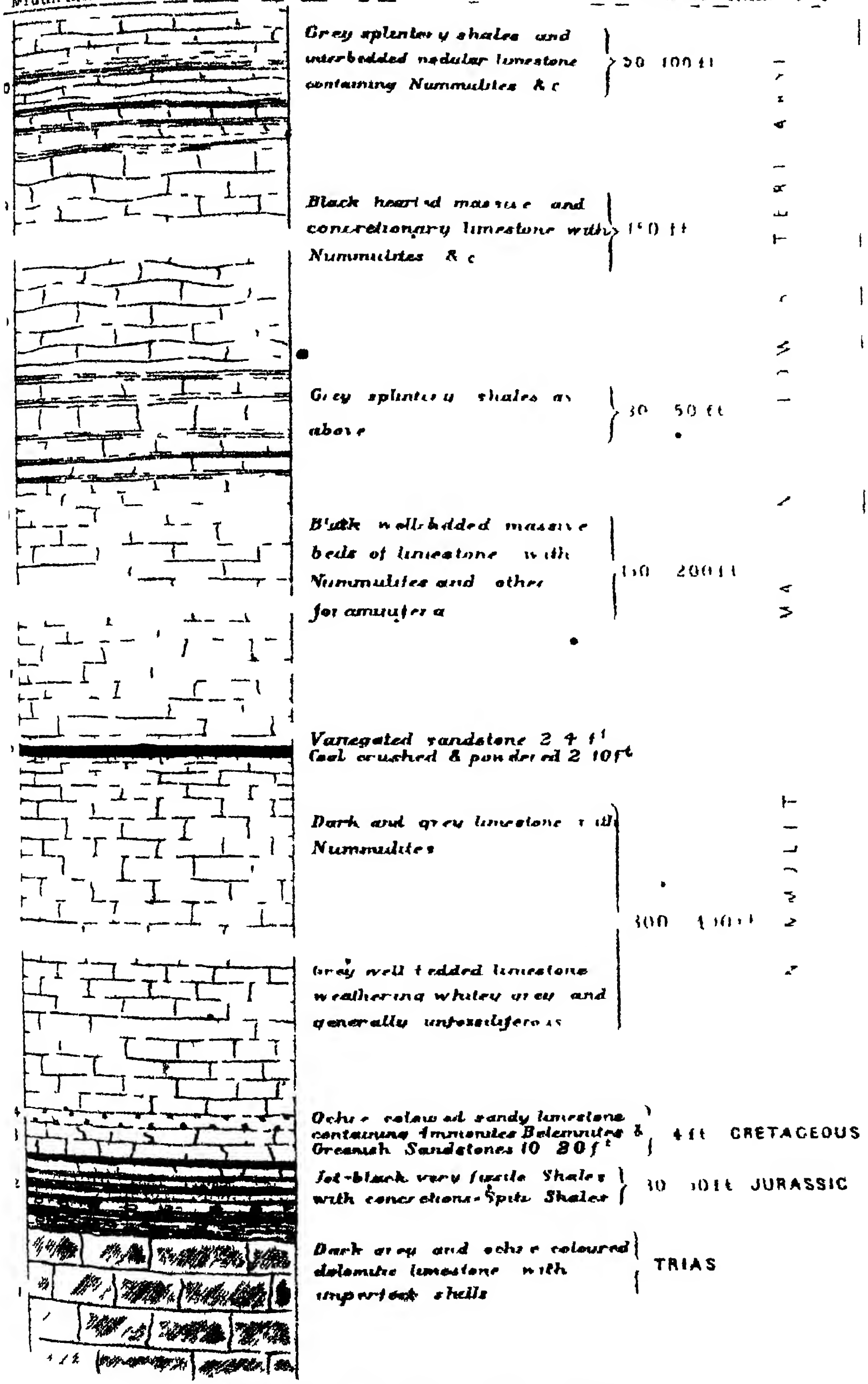

FIG I VERTICAL SECTION, DORE RIVER

Preliminary Note on the Coal Seam *of the* Dore Ravine, Hazara, *by* C. S. MIDDLEMISS, B.A., *Geological Survey of India.* (With two plates.)

MR. D. MORRIS, Executive Engineer in charge of Coal Mines, North-Western Railway, and Mr. C. Jones, Assistant Engineer, Hazara Sub-division, have each described the occurrence of the coal in the Dore ravine as lying with the adjacent limestones in the form of an anticlinal arch cut through by the river action. This is a very pardonable mistake; for the first view up the valley as we go east from Dhamtour certainly gives one this wrong impression. On the north side of the river we see a dip to the north or north-west, and on the south side a dip to the south-east—facts which easily lend themselves to the above conclusion.

Previous experience of Himalayan sections had prepared me for putting but slight faith in an apparently simple condition such as this; but before I could get to work to unravel even the circumscribed area embraced in this note, it was necessary to become thoroughly acquainted with the normal lie and sequence of the strata. This was not so easy a task as I expected: I was delayed by many slight mistakes and imperfect representations of the rocks in Mr. Wynne's unfinished map of the district, and by the inclement season of the year, which made hill-traversing difficult.

Being now in a position to lay bare the essential points in the rock-structure of the Dore ravine near Hewson's and the Public Works Department mines, I take the opportunity of this short note to state the case as briefly as possible, leaving all detailed remarks, and the purely scientific aspect of the questions involved, for a subsequent finished report.

Round about the Dore valley and neighbourhood there are very many exposures of carbonaceous shales with associated sandstones, which from fossil evidence have been assigned by Dr. Waagen to the Jurassic epoch, and as the probable equivalents of the Spiti shales. It is necessary once for all to state that these black and coaly-looking strata have nothing to do with the Dore coal. Their horizon is much lower in the natural chronological sequence of the rocks. The real coal-bearing stratum, as exposed in Hewson's mine, the Public Works Department mine, and in other localities, is at the surface a very unsuspicious-looking, rather coarse, variegated white and red sandstone; sometimes weathering into a hard rock of millstone-grit type, and sometimes crumbling into a loose sand or sand-rock mixed with clay in patches. It is usually about 6 feet thick. In some places specks, blotches and patches of coal or carbonaceous clay can be seen in the river cuttings, but not often; whilst on the higher hill-sides the sandstone rings under the hammer and gives no token of mineral wealth below.

In the vertical section (Pl. 1), I have expressed the lithological features and the chronological sequence of the rock formations above and below the coal as they would appear in a perfectly undisturbed normal section. This is the order in which they are seen some little distance above Hewson's mine, constituting the high mural scarps on the right bank of the Dore ravine, with the exception that they are tilted up sharply with a dip of about 40° north-north-west at the surface of the ground.

In such guise they are drawn on the right-hand side of the horizontal sketch section (Pl. 2). On the left-hand side of that section, which coincides with the south bank of the Dore ravine, the same rocks are observable; and from their

dipping in the opposite direction at the surface arose the misconception that an anticlinal fold was therein implied. It will be seen, however, that the *order* of the strata on the left side of the section is not the same as on the right side. In fact, it will be seen that the order is inverted. This is the whole secret of the matter.

The difficulties implied by such a structure are fatal to the development here of a large and important coal-field; for such a structure tells a tale of so intense a crushing of the mountain region that all the rocks have come within 10° or 20° of the vertical when traced to the deep. Had the crushing of the region been less severe, we should have had the strata thrown into gentle folds of anticlinal and synclinal, and a coal basin might have been possible. As it is, the strata have been bent back upon themselves and have split along fold-faults marked F on the horizontal section (Pl. 2).

It is owing to the tendency of the free edges of rock beds to subside slightly down hill that we have the comparatively gentle dip of about 40° at the surface both in Hewson's and the Public Works Department mines. Whereas gorge-like sections, such as that in the Hertoh (Harno) R., show that when the heart of the mountain is reached the dip is very nearly vertical.

The question has been mooted whether these coal exposures are mere discontinuous "pockets," or whether they belong to a true seam which may be trusted to continue for some distance. I have no hesitation in saying that the latter is the truth with regard to them. They are not of the nature of the coal that many years ago was reported in the Upper Tertiary Sandstones in the vicinity of Murree, but which was proved by Mr. Medlicott to be of the "pocket" nature, due to the entombing of a stray tree-trunk or two. On the other hand, they are undoubtedly portions of a continuous band or seam of coal of lower nummulitic age, well known in the Salt-Range and the Jamu area. Possibly this seam may here and there locally prove to have been nipped out to nothing and to have swelled in the neighbourhood beyond its proper thickness.

From the structural considerations given above, it follows that in working the coal on the north side of the river the engineer must be prepared for the dip of the bed becoming continuously steeper, until within about 200 or 300 feet from the surface it assumes an angle of 70° or 80°; whilst on the south side it will reach the vertical about the level of the Dore ravine (in the neighbourhood of the Public Works Department shaft), then pass the vertical, until it rests at 70° or 80°, dipping in the same direction as the coal on the north side. After this it will become cut off by the fold-fault along the river.

These circumstances will, of course, necessitate deep and expensive working, bu I have a sanguine belief that a large supply of serviceable fuel may be extracted from these outcrops.

The locality of the Public Works Department mine should be first tested by an adit driven in at the river level.

On the north side of the river the outcrop from Hewson's runs away north-west up the hill slope, by what will probably be found to be a set of broken lengths. East of Hewson's there is a cross-fault running up the stream towards the north-west with an upthrow to the north-east of about 300 feet. Hence the coal-bearing bed has to be sought at a considerable height above Hewson's in that direction. In my full report these details will be illustrated by a map. At present I may say that

the bed follows the base of the first inaccessible scarp found up the stream north of Hewson's. It gradually descends towards the stream-bed west of Mohar village.

Should the exploitation of the coal be undertaken soon, I can give particular directions on the spot as regards further operations.

GEOLOGICAL SURVEY OF INDIA DEPARTMENT.

TRI-MONTHLY NOTES.

5. ENDING 31ST OCTOBER 1890.

Director's Office, Calcutta, 31st October 1890.

The staff of the Survey is at present disposed in the following parties:—

Madras Party.—R. B. FOOTE, F.G.S., Senior Superintendent, Bellary District.

Burma Party.—THEO. W. HUGHES HUGHES, A R S M., Superintendent.
FRITZ NOETLING, PH D., Palæontologist.

Baluchistan Party.—R D. OLDHAM, A.R.S.M., 1st Grade Deputy Superintendent.
Sub-Assistant Kishen Singh.
Sub-Assistant Hira Lal.

Hazara Party.—C. S. MIDDLEMISS, B.A., 2nd Grade Deputy Superintendent.

Darjiling and Sikkim.—P. N. BOSE, B Sc., 2nd Grade Deputy Superintendent.

Head Quarters, Calcutta.—The Director.
C. L. GRIESBACH, C.I.E, Superintendent.
T. D. LATOUCHE, B.A., 2nd Grade Deputy Superintendent.
P. N. DATTA, B Sc., Assistant Superintendent.
T. H. HOLLAND, Assistant Superintendent.

The Director was on tour in the Madras Presidency in August and September, a good part of the time being spent at Hyderabad in connection with the question of demarcating the limits of the Singareni Coal-field and the auriferous tract of Dhárwár rocks in the Raichur Doab. The settlement of the leasing of this coal-field and the gold area, following on the completion of the prospecting lease granted by His Highness the Nizam's Government to the Hyderabad (Deccan) Company, had come before the Resident, Sir Dennis Fitz-Patrick; and it was contended by the Hyderabad (Deccan) Company that no definite limitation of these areas could be made by a geologist or indeed anybody else, for which rather novel opinion they relied on their mining expert, who had paid a short visit to the country. The Singareni Coal-field being, however, an isolated tract of the lower Gondwana series

entirely surrounded by crystalline and metamorphic rocks on which also the coal-rocks lie, there is really no difficulty in determining an encircling rim of these latter rocks, within which the coal-field lies and outside of which there are no branches or outliers.

Similar objections, which are however somewhat more reasonable, were raised with regard to the auriferous tracts of Dhárwárs in the Raichur Doab; it being of course impossible to say definitely that there could be no gold in the quartz-reefs and other fissure infiltrations among the rocks outside of the known area of Dhárwárs. The prevalence and restriction of auriferous reefs within certain tracts of the Dhárwár series is, however, so well established now, that the selection of sites for gold development must, for all practical purposes, lie within the Dhárwár belts; while the area of these has been determined with sufficient accuracy in the Raichur Doab, for all purposes of mineral concession or leasing. In other words, there is really no use in looking for auriferous reefs outside this tract in the Doab.

The reported occurrence of coal in the Coimbatore District was found to be attributable to the long-known exhibition of poor seams of lignite in the patches of later tertiary strata occasionally found in the adjacent Malabar District; at least, the locality mentioned appears to be really in the Malabar District; and until more definite information regarding it is available, further examination is unnecessary.

Arrangements were made for an immediate visit to the reported gold tract in Kolegal where, as it turns out, the old mine workings are in reefs which do not traverse the Dhárwár series. Mr. Foote will carry on his survey of the continuation of the Mysore gold tract into British territory in the Cuddapah District.

The boring for an artesian well at Lucknow was visited in October, with a view to advising the Government of North-Western Provinces and Oudh regarding the sinking of another well. The first boring, on reaching a depth of 1,189 feet, struck a porous stratum from which good water rose to a height of 29 feet above the hot-weather level of the Gumti river, which, however, only flowed out at the rate of 10 gallons a minute. This supply being far below the quantity required, the bore hole was run down to 1,336 feet, in the hope of reaching a better and freer discharge, but without success, when it was found impracticable to drive the tubing deeper. The proposal has now been put forward, that a fresh attempt should be made with tubing of a larger diameter, which it is assumed may, under the experience gained, be run down to about 2,000 feet.

This will, of course, entail a larger outlay: but, seeing that the fact of the existence of a sheet of water, with a head, has been now proved to exist under the Gangetic alluvium, the legitimate inference is that others will be met with at a somewhat greater depth likely to yield the larger and freer discharge desiderated. The settlement of this question of underground water-supply is of such vital importance to the province itself and to the next lower tracts of the Gangetic plain, that a stoppage of the exploration on its present stage would only leave room for renewed—and then inexperienced—attempts in the future.

Mr. Theo. W. H. Hughes is expected back from leave about the middle of November. He will proceed direct to Mergui *viâ* Penang to resume his exploration for tin.

Mr. C. L. Griesbach will shortly leave to take up work on the N.-W. Frontier, stopping on the way to examine the reported find of coal in Pinjaur.

Mr. R. D. Oldham has been deputed to accompany the Zhob Expedition, with a view to examining the reported occurrence of oil in that country.

Mr. T. D. LaTouche proceeds to Ranchi in order to take up the thorough exploration by borings and small pits of the Daltonganj Coal-field. It has been arranged that an officer of the Public Works Department should accompany Mr. LaTouche in order to superintend the putting down of borings at the places indicated by that officer. For this purpose, one of the new sets of boring plant recently received from the Secretary of State for India will be used.

Mr. P. Lake, on return from privilege leave early in January, will probably be deputed to Burma in place of Mr. LaTouche.

Mr. P. N. Datta will also be leaving about the middle of November for Assam, where he has been deputed to examine certain coal outcrops in the Garo Hills.

Mr T. H. Holland, who was recently appointed to this Department by the Secretary of State for India, joined his appointment in October. He has, for the present, been placed in charge of the Museum and Laboratory.

List of Reports and Papers sent in to office for publication or record during August, September, and October 1890.

Author.	Subject	Disposal
R. B FOOTE . . .	Translation from the German, of Note by Dr Johannes Walther "On veins of graphite in decomposed gneiss (Laterite) in Ceylon"	Will be published in the 'Records of the Geological Survey of India," Vol. XXIV, part 1.
R. D. OLDHAM . . .	Note on the Deep Boring at Lucknow	Published in the 'Records of the Geological Survey of India,' Vol. XXIII, part 4
P. N. BOSE . . .	Report on the Darjiling Coal between the Lisu and the Ramthi rivers.	Ditto ditto.
" . . .	Extracts from Journal of a trip to the glaciers of Pandim, Kabru, &c.	Will be published in the 'Records of the Geological Survey of India," Vol. XXIV., part 1.
C. S. MIDDLEMISS . .	Note on the coal seam of the Dore River, Hazara	Published in the "Records of the Geological Survey of India,' Vol. XXIII part 4
P LAKE	Note on the basic eruptive rocks of the Kaddapah area	Ditto ditto.
"	Report on the Geology of South Malabar.	Will be published as "Memoirs of the Geological Survey of India," Vol. XXIV, part 3
P. N. DATTA . . .	Compilation of Index to the first twenty volumes of the 'Records of the Geological Survey of India."	Published as a Supplement with the 'Records of the Geological Survey of India," Vol XXIII., part 4.
R. LYDEKKER . . .	Note on some fossil Indian Bird Bones.	Published in the "Records of the Geological Survey of India," Vol. XXIII., part 4.

List of Assays and Examinations made in the Laboratory, Geological Survey of India, during the months of August, September, and October 1890.

Substance.	For whom.	Result.
Alluvial soil, for gold .	MACKILLICAN & Co., Calcutta.	
Quartzose schist, for gold.	F. C. LETHORN, Calcutta.	
Coal, from a mine about 3 miles due east from Kalka, on the right bank of Kassolia river in Kawll Forest.	Commissioner and Superintendent, Delhi Division.	Moisture . . . . . 2·34 Volatile matter . . . 17·68 Fixed carbon . . . 39·92 Ash . . . . . . 40·06 TOTAL . 100·00 Ash—dark red. Does not cake, but sinters slightly.
Coal, found between the Singanama and Betul Roads near Burkoe, Chindwara District.	Secretary to Chief Commissioner, P. W. D., Central Provinces.	Moisture . . . . . 5·62 Volatile matter . . . 26·92 Fixed carbon . . . 48·74 Ash . . . . . . 18·72 TOTAL . 100·00 Ash—light red. Does not cake, but sinters slightly.
Quartz, for gold . .	MACKILLICAN & Co., Calcutta.	
Galena, in quartz . .	R. W. BACHRACH, Calcutta.	
11 specimens of minerals for determination.	C. T. AMBLER, Monghyr.	
Quartz, for gold . .	J. M. STONEY, Calcutta.	
Pegmatite, for gold .	P. RICHARDS, 4, Clive Row, Calcutta.	
2 specimens of minerals for determination.	Ditto ditto.	
Specimen of mineral sent for determination.	W. M. SMITH, Sub-Divisional Officer, Deogarh.	= Garnets.
Copper, from mines near Kashgar.	LIEUTENANT BOWER, through DR. G. WATT.	Insoluble matter . . . ·25 Cu (Copper) . . . 98·17 Pb. (Lead) . . . ·35 Undetermined . . . 1·23 TOTAL . 100·00
Quartz, for gold . .	J. B. CASS, 12, Lall Bazar, Calcutta.	
Quartz, for gold . .	KILBURN & Co., 4, Fairlie Place, Calcutta.	
Pegmatite, for gold .	MACKILLICAN & Co., Calcutta.	
Quartz, for gold . .	A. SIMSON, 4, Fairlie Place, Calcutta.	
Copper pyrites . .	E. C. GRAVE, 44, Wellesley Street, Calcutta.	
Coal, from the Hertoh River, Hazara.	C. S. MIDDLEMISS, Geological Survey of India.	*N. Exposure.* / *S. Exposure.* Moisture . 3·04 / 2·94 Volatile matter. 9·80 / 5·08 Fixed carbon 80·86 / 11·86 Ash . . 6·30 / 80·12 TOTAL . 100·00 / 100·00 Does not cake. Ash—brick red. / Does not cake. Ash—pale buff.

List of Assays and Examinations made in the Laboratory, Geological Survey of India, during the months of August, September, and October 1890—continued.

Substance.	For whom.	Result.
Quartz, for gold . .	A. SIMSON, 4, Fairlie Place, Calcutta.	
Quartz, for gold . .	A PEPPÉ Ranchi.	
Gneiss, with copper pyrites, for gold and copper.	DR. LAMB, 5, Old Court House Street, Calcutta.	
3 specimens of minerals for determination.	T. B. CASS, 1a, Lall Bazar, Calcutta.	
Carbonate of lead .	E. REUBEN & Co, 6, Pollock Street.	

Notifications by the Government of India during the months of August, September, and October 1890, published in the "Gazette of India," Part I.—Appointment, Confirmation, Promotion, and Retirement.

Department.	No of order and date.	Name of Officer	From	To	Nature of Appointment, &c	With effect from	Remarks.

Notifications by the Government of India during the months of August, September, and October 1890, published in the "Gazette of India," Part I.—Leave.

Department	No of order and date,	Name of Officer.	Nature of Leave	With effect from	Date of Return	Remarks.
Revenue and Agricultural Department.	$\frac{470}{93-12}$ S, dated 20th June 1890.	T. H. D. LaTouche .	Privilege leave.	2nd July 1890		
Ditto .	$\frac{1176}{93-12}$ S., dated 20th October 1890.	Ditto . .	Extension on duty for two weeks	2nd October 1890.	9th October 1890.	
Ditto .	$\frac{930}{93-21}$ S., dated 8th September 1890	P. Lake . .	Privilege leave.	8th October 1890.		

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